GANNETT FLEMING

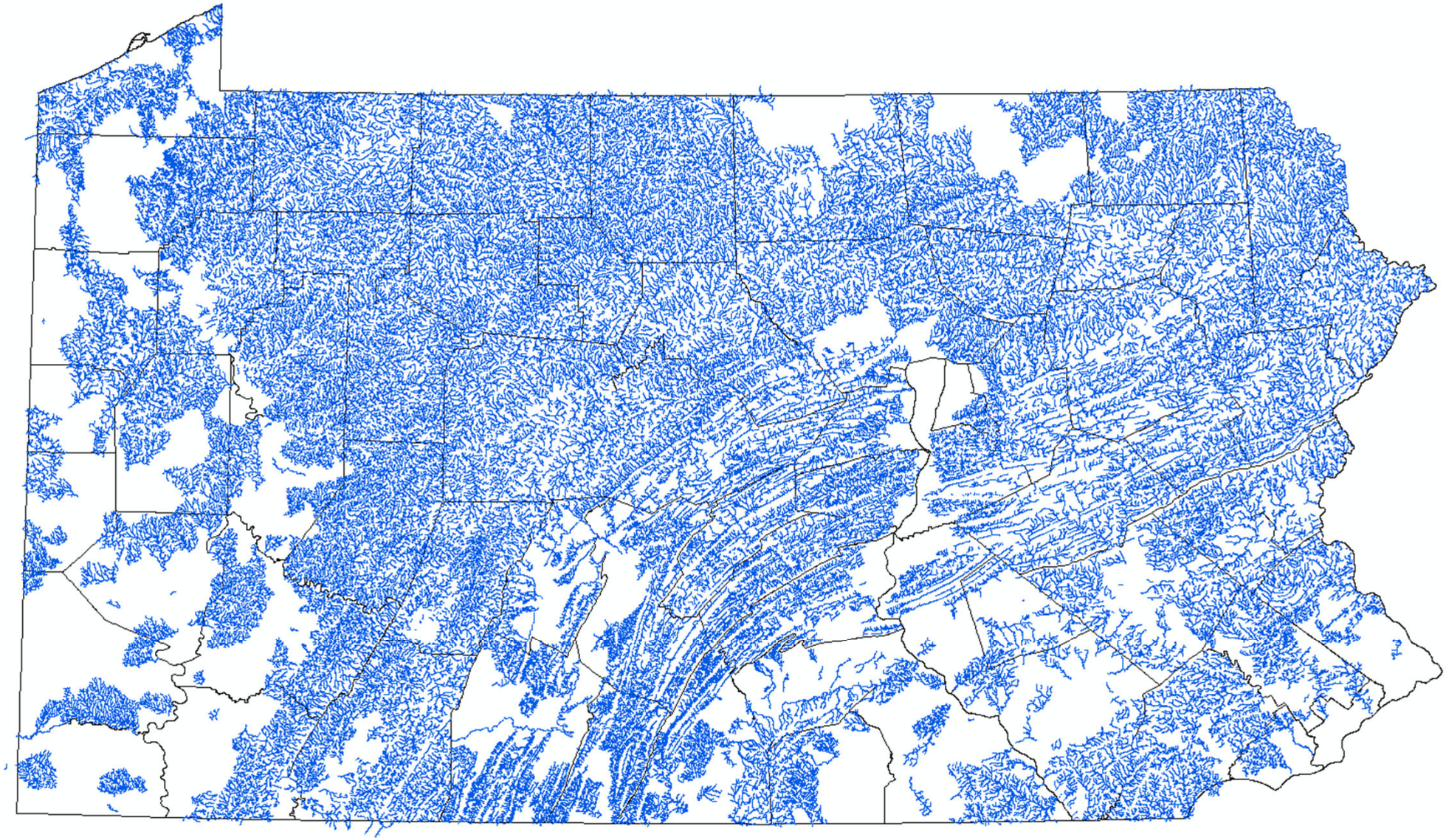
HOT TOPIC:
URBAN HEAT ISLANDS AND IMPACTS TO WATER AND LAND USE REGULATIONS

Presented by:
Nathan Walker, AICP, Sr Water Resources Planner
Mehdi Ketabchy, EIT, ENV SP, Water Resources Engineer

PA Chapter of the American Planning Association

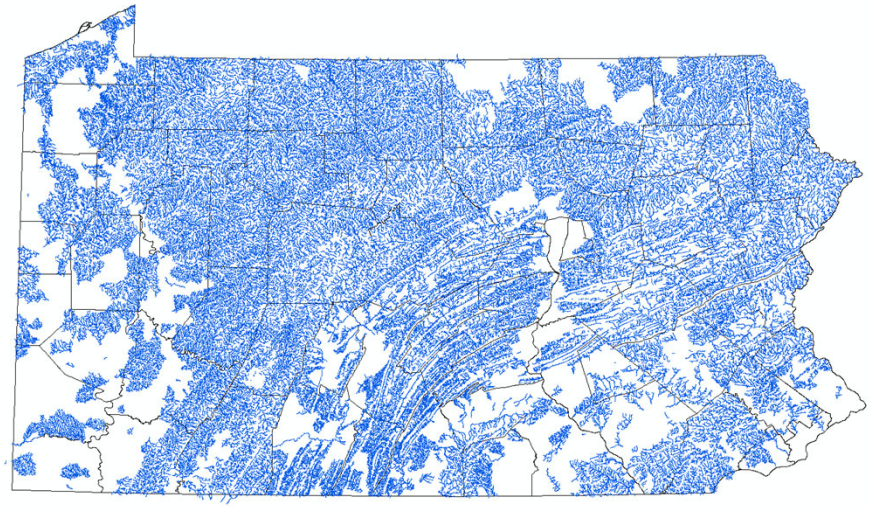
Annual Conference, Lancaster, PA

October 3, 2022, 3:45 – 5:15pm



Session Agenda

- Warm up: Impact of regulations on land development
- Costs and benefits of stormwater management requirements
- Stormwater management regulations – changing over time
- Interrelationship of dissolved oxygen, stream temperature, and land use change
- Modeling thermal pollution mitigation practices
- Adapting regulations to address thermal pollution impacts
- Affect of new regulations on development patterns



Warm Up

Assumptions:

1. PA municipalities oversee land use.
2. PA municipalities operate in diverse locations.
3. PA municipalities have diverse drivers and priorities.

Question:

For the municipalities you work in – what land use regulations are most impactful?

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Warm Up

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Question:

For the municipalities you work in – what land use regulations are most impactful?

But first:

What does impactful mean?

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What does impactful mean?

Depends on who you represent.

Land use regulations impact different parties in different ways:

Property Owner	Elected Officials/Community
Cost of planning and design	Community character
Cost of construction	Economic development
Use of property	Infrastructure
Return on investment	Taxes
Cost of O&M	Traffic

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Warm Up

Assumptions:

1. PA municipalities oversee land use.
2. PA municipalities operate in diverse locations.
3. PA municipalities have diverse drivers and priorities.
4. Land use regulations impact property owners and the community differently.

Question:

For the municipalities you work in – what land use regulations are most impactful?

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Question:

For the municipalities you work in – what land use regulations are most impactful?

M-945A (7-14)

pennsylvania
DEPARTMENT OF TRANSPORTATION

APPLICATION FOR HIGHWAY OCCUPANCY PERMIT

Effective 1/1/2022

Montgomery County Conservation District
143 Level Road
Collegeville, PA 19426
Phone: (610) 489-4506 | Fax: (610)489-9795
www.montgomeryconservation.org

For District Use Only

Entry #:
NPDES Permit #:
Chapter 102 Review Fee: Check #:
NPDES Fee: Check #:
Disturbed Acre Fee: Check #:
Expedited Fee: Check #:

APPLICATION FOR CHAPTER 102 and/or NPDES PERMIT REVIEW

?

Township of Upper Gwynedd, PA / Part II: General Legislation

Chapter 168 **Subdivision and Land Development**

3150-PM-BWEW0500 Rev. 4/2021
Form

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERWAYS ENGINEERING AND WETLANDS

CHAPTER 105 WATER OBSTRUCTIONS AND ENCROACHMENT GENERAL PERMIT REGISTRATION

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Question:

For the municipalities you work in – what land use regulations are most impactful?

- Permitted uses
- Lot size and density
- Setbacks
- Land cover limits and intensity
- Design process
- Approval process
- Infrastructure requirements
- Parking requirements
- Landscaping requirements
- Environmental protection requirements
- Earth disturbance
- Highway occupancy
- Historic resources

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Purpose of land use regulations:

- Influence the development that occurs on the property
- Protect neighbors and the community from impacts that can spill outside the property boundary:
  - Solar exposure
  - Accessibility
  - Transportation
  - Recreation
  - Stormwater

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Land use regulations:

- Influence the development that occurs on the property
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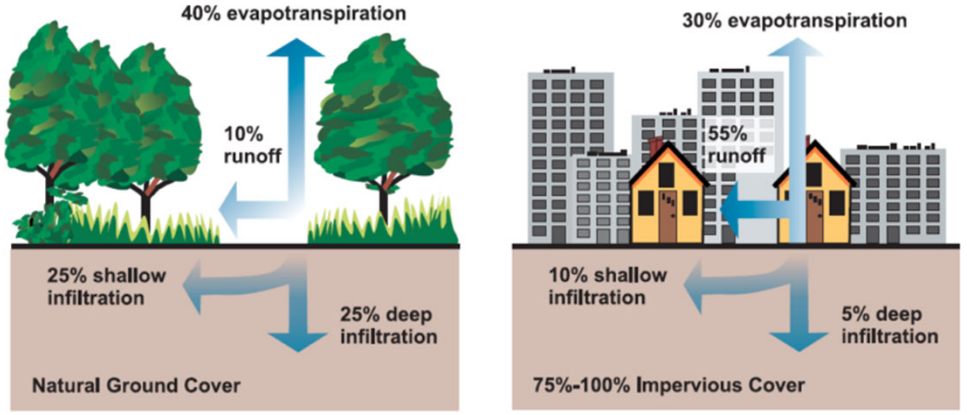
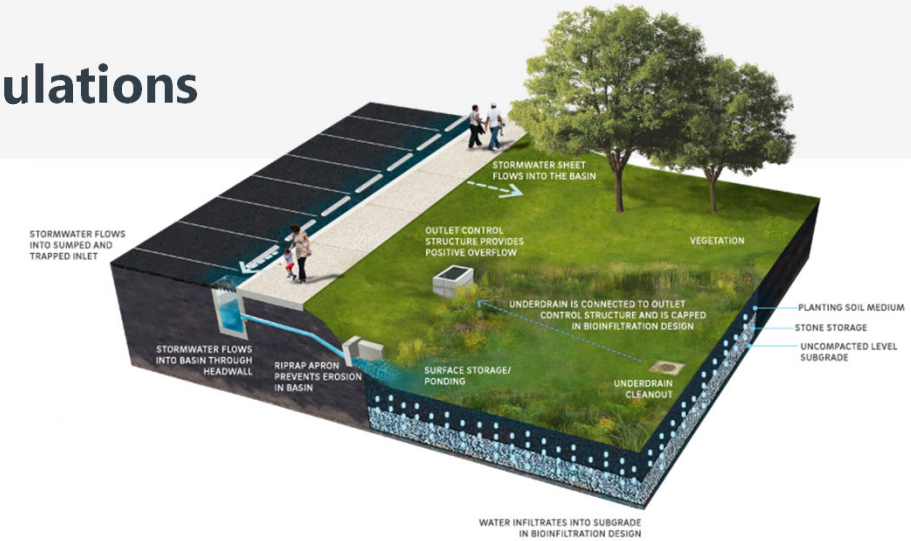
  - Solar exposure
  - Accessibility
  - Transportation
  - Recreation
  - Stormwater
    - Discharge volume
    - Release rate
    - Water quality

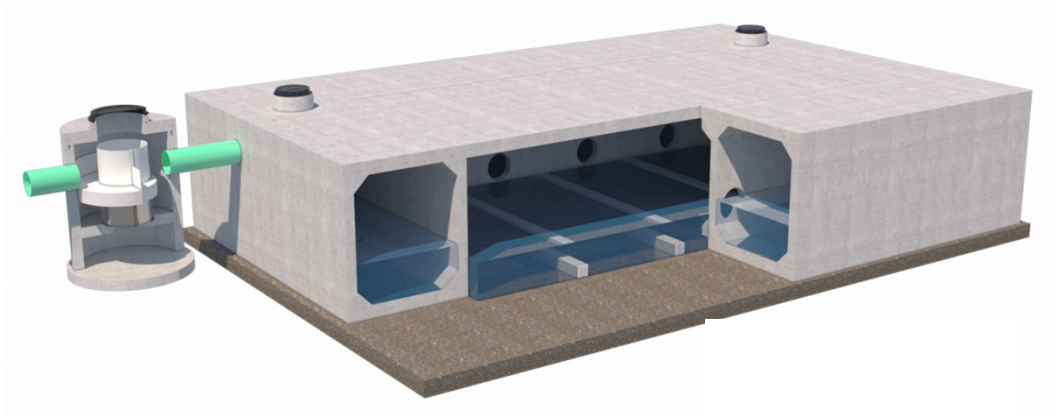


Purpose of stormwater management regulations

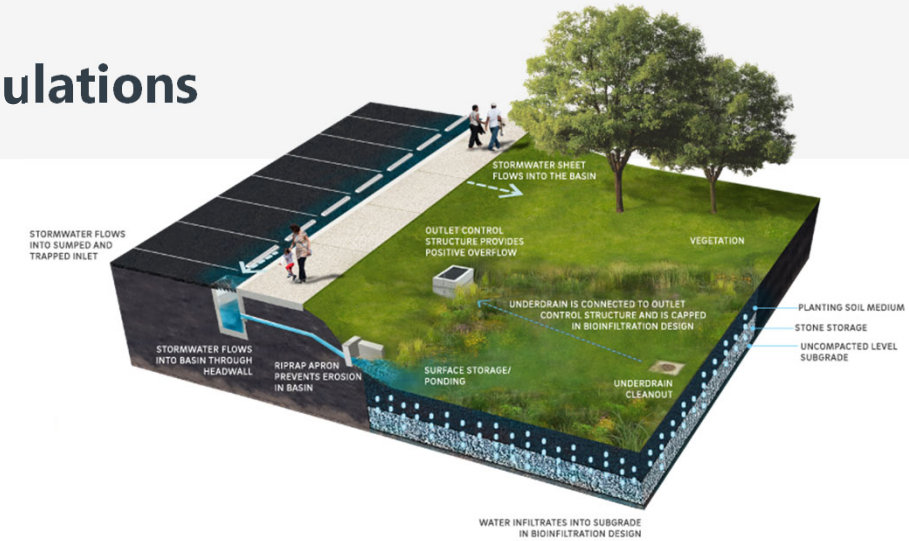
Mimic hydrology

- Mitigate flooding
- Protect water quality and habitat
- Promote groundwater infiltration
- Prevent floodplain development





Purpose of stormwater management regulations



Mimic hydrology

- Mitigate flooding
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What are the impacts of stormwater management regulations on land development design?

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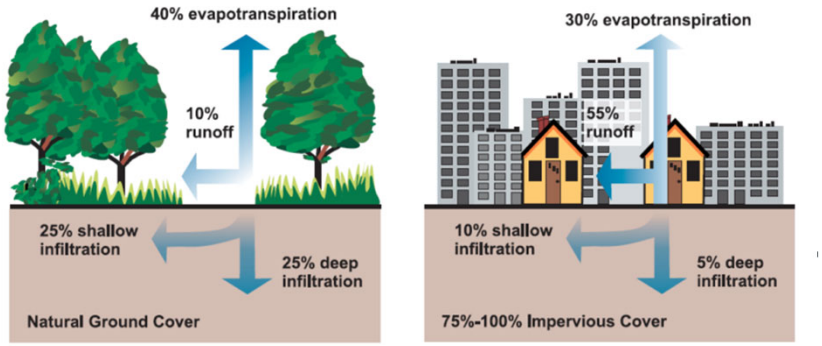
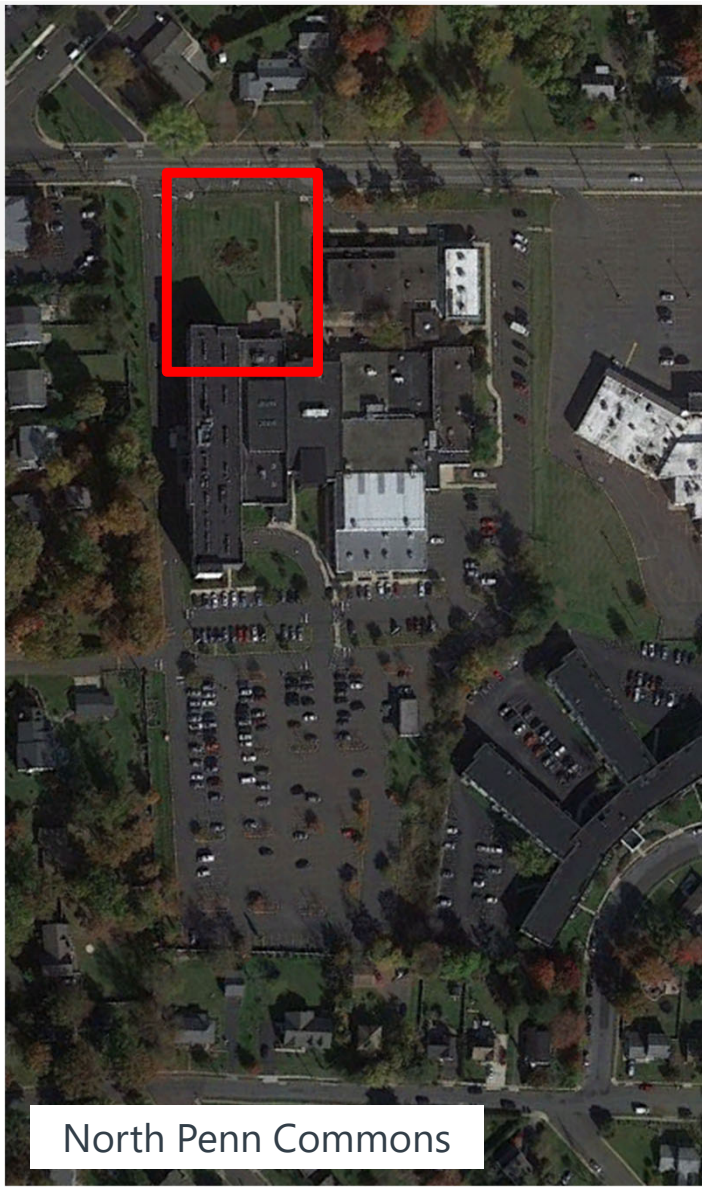


Impacts of stormwater management regulations

- Mimic hydrology
- Expand green space
- Limit land use intensity
- Increase cost of development
- Increase cost of redevelopment
- Increase carrying cost of infrastructure (O&M, repair, replacement)

How do we prevent stormwater management regulations from being a barrier to desirable development?



North Penn Commons

Question:

What were the water quality pollutants of concern in:

1970?

1985?

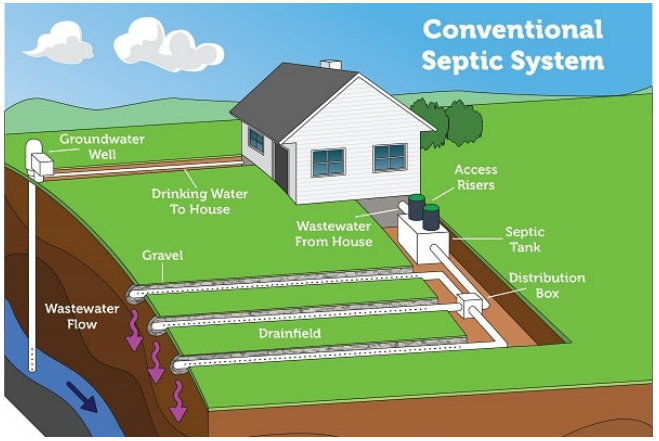
2000?

Question:

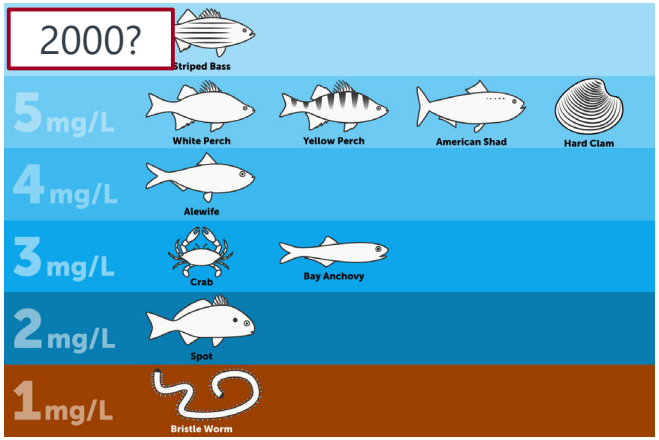
What were the water quality pollutants of concern:

1970?

1985?



2000?



How about 2030?

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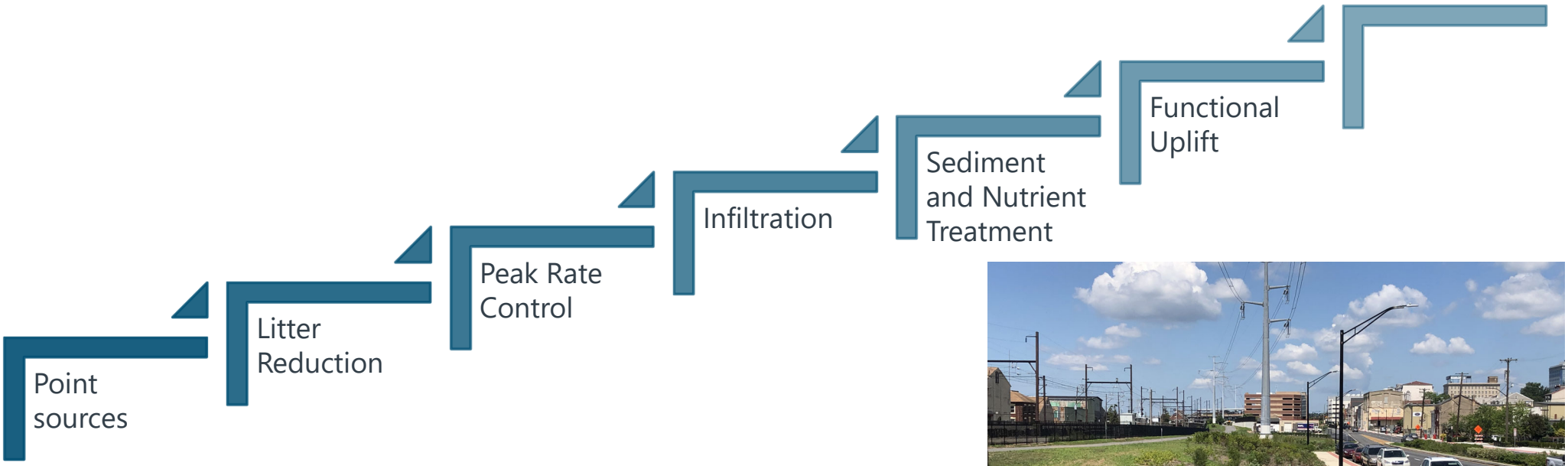
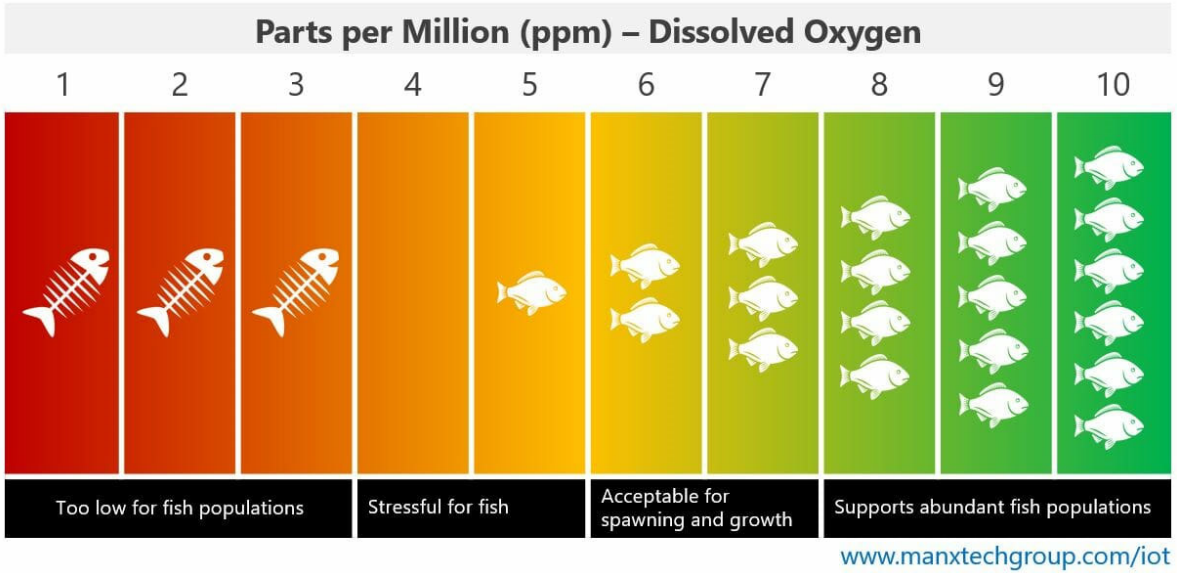
Evolution of minimum water quality standards



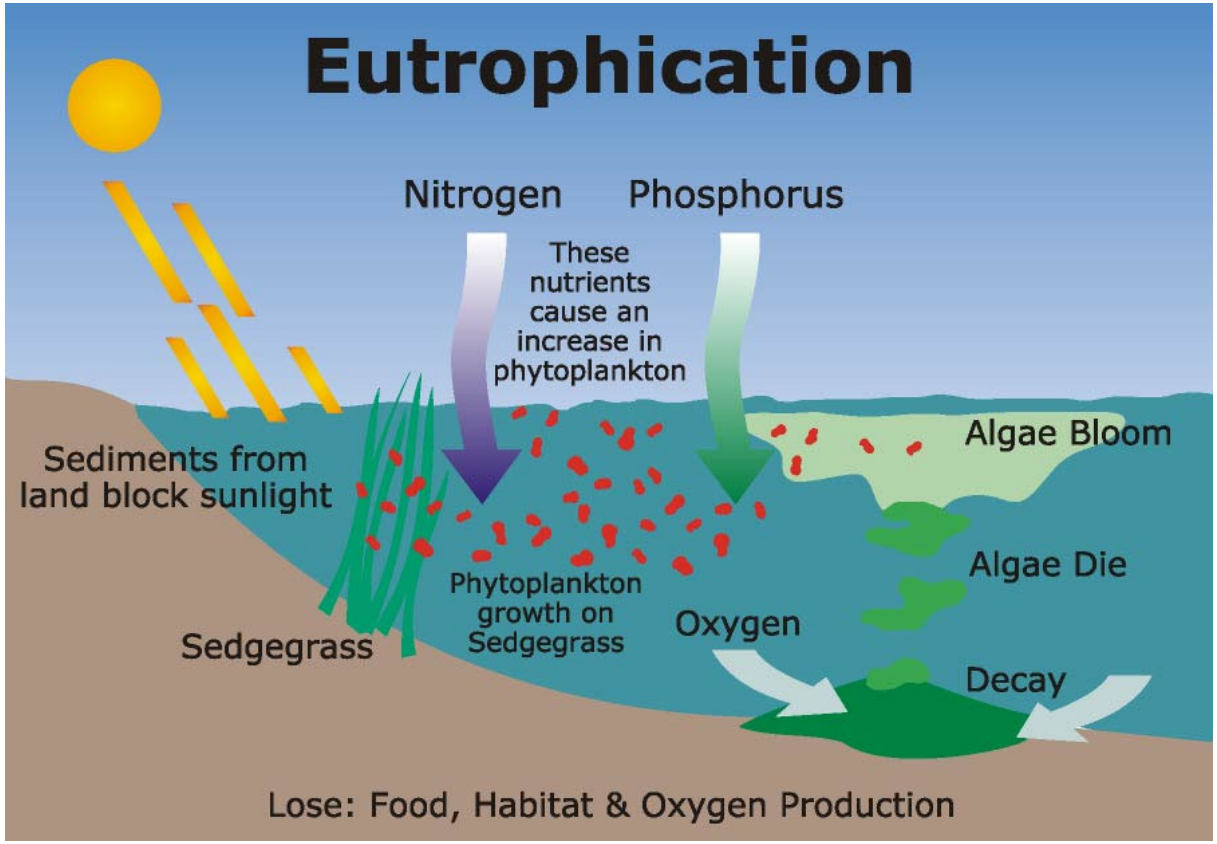
Consider the growing investment in water quality infrastructure

How will land use regulations that address stormwater adapt to climate change?

- Flood mitigation
  - Permitted uses in the riparian corridor
  - Floodplain management
  - NOAA public comment on Atlas 15 precipitation frequency standards
- Water quality
  - Dissolved oxygen
    - Sediment
    - Nutrients
    - Temperature



Factors Impacting Dissolved Oxygen



Let's discuss:

- The influence of land use change on dissolved oxygen
- How do we prevent stormwater management regulations from being a barrier to desirable development?

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Awareness of thermal pollution as an issue

3800-PM-BCW0100j Rev. 4/2018
Model Ordinance
pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

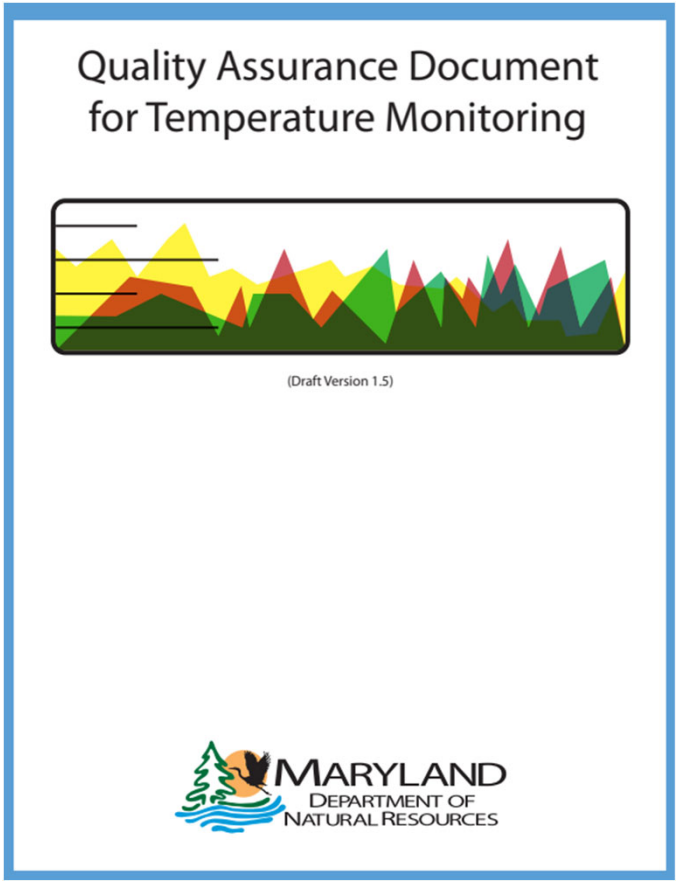
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
STORMWATER DISCHARGES FROM
SMALL MUNICIPAL SEPARATE STORM SEWER SYSTEMS (MS4s)
2022 MODEL STORMWATER MANAGEMENT ORDINANCE

ARTICLE III – STORMWATER MANAGEMENT STANDARDS

Section 301. General Requirements

G. All regulated activities shall include such measures as necessary to:

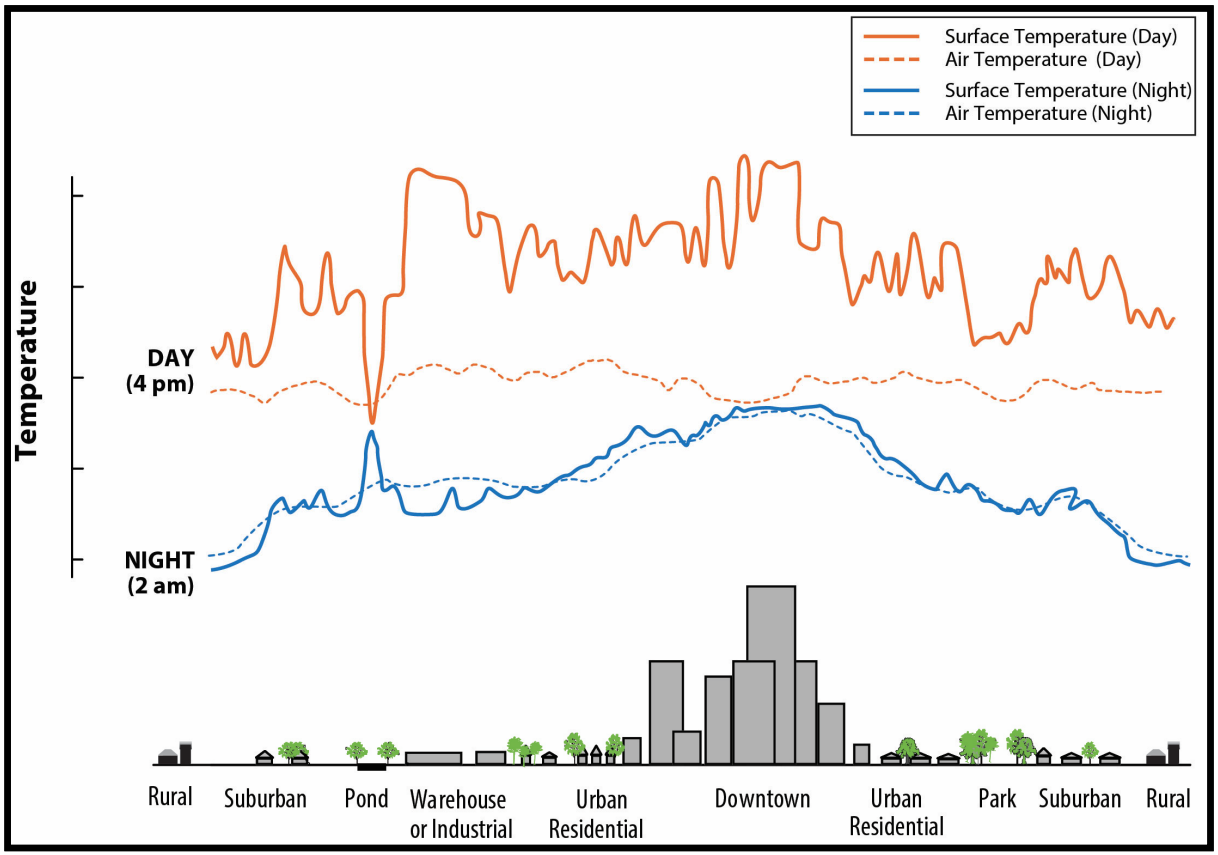
1. Protect health, safety, and property.
2. Meet the water quality goals of this Ordinance by implementing measures to:
   a. Minimize disturbance to floodplains, wetlands, and wooded areas.
   b. Maintain or extend riparian buffers.
   c. Avoid erosive flow conditions in natural flow pathways.
   d. Minimize thermal impacts to waters of this Commonwealth.
   e. Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible.



Urban heat island *(source: USEPA)*

Where structures are highly concentrated, and greenery is limited…

- Causes:
  - Reduced natural landscapes
  - Urban material properties
  - Urban geometry
  - Heat generated from human activities
  - Weather and geography
- Cooling strategies:
  - Trees and vegetation
  - Green roofs
  - Cool roofs and pavements
  - Smart Growth techniques

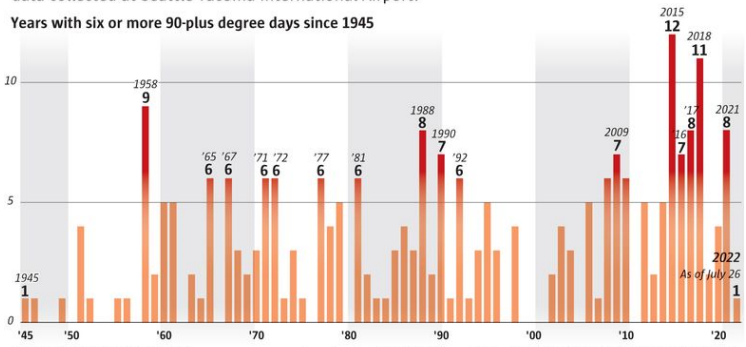


Seattle

Seattle's hottest summers

Between 2015-2021, there were five years with at least seven 90-plus degree days, according to data collected at Seattle-Tacoma International Airport.

Years with six or more 90-plus degree days since 1945



Source: National Weather Service

Reporting by GENE BALK, graphic by MARK NOWLIN / THE SEATTLE TIMES

Cleveland

Were all those 90s in June normal?

BY METEOROLOGIST ASHLEY BATEY | OHIO
PUBLISHED 11:45 AM ET JUL. 07, 2022

Hartford

In 2050, CT is expected to see 44 days with temps over 90 degrees

According to a report by the non profit organization Union of Concerned Scientists, if global emissions trends continue, the number of days with temperatures over 90 degrees in Hartford will increase to 44 by mid-century. As of 2019, the average is 11 days a year.

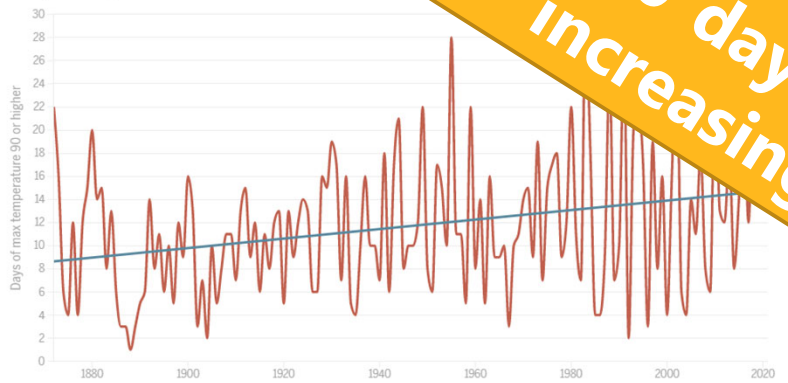
Chicago

- The city of Chicago could see **30 more days** per year rise above 100 degrees Fahrenheit (°F) under "high" greenhouse gas emissions scenario
- Under lower emissions, Chicago's new summe ex could increase to around 93 °F by the end of the century—similar to current su in Atlanta, Georgia.

Boston

It's not just you, 90 degree days are on the rise

Total number of days per year with recorded temperatures of 90 degrees
159 days remaining.



Source: Northeast Regional Climate Center • Temperatures are based on measurements from three Boston-area weather stations.
JOHN HANCOCK/GLOBE STAFF

The number of <90° days is increasing

San Antonio

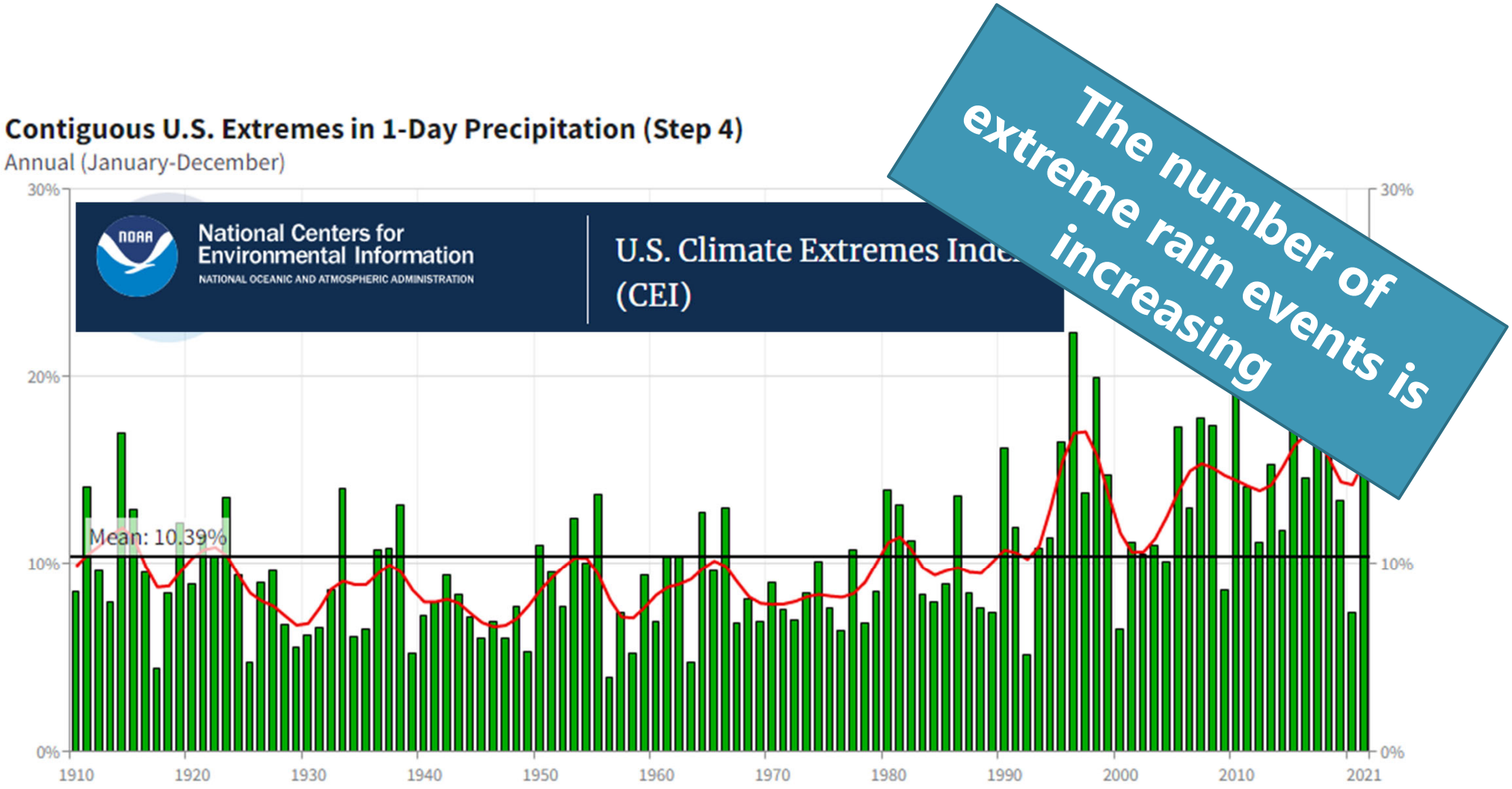
The Washington Post
Democracy Dies in Darkness

San Antonio had 17 days of triple-digit heat in June. The norm is two.

Numerous Texas cities observed a siege of 100-degree days in June amid extreme drought

By Ian Livingston

Updated June 30, 2022 at 6:21 p.m. EDT | Published June 30, 2022 at 4:29 p.m. EDT


Contiguous U.S. Extremes in 1-Day Precipitation (Step 4)
Annual (January-December)
National Centers for Environmental Information
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. Climate Extremes Inde
(CEI)
Mean: 10.39%
30%
20%
10%
0%
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2021
The number of extreme rain events is increasing

Heat Islands + Cloud Bursts = Thermal Loading

If thermal loading is a threat to water quality, will it be regulated?

How would thermal loading regulation impact land development patterns?

Urban development impacts on increased water temperatures

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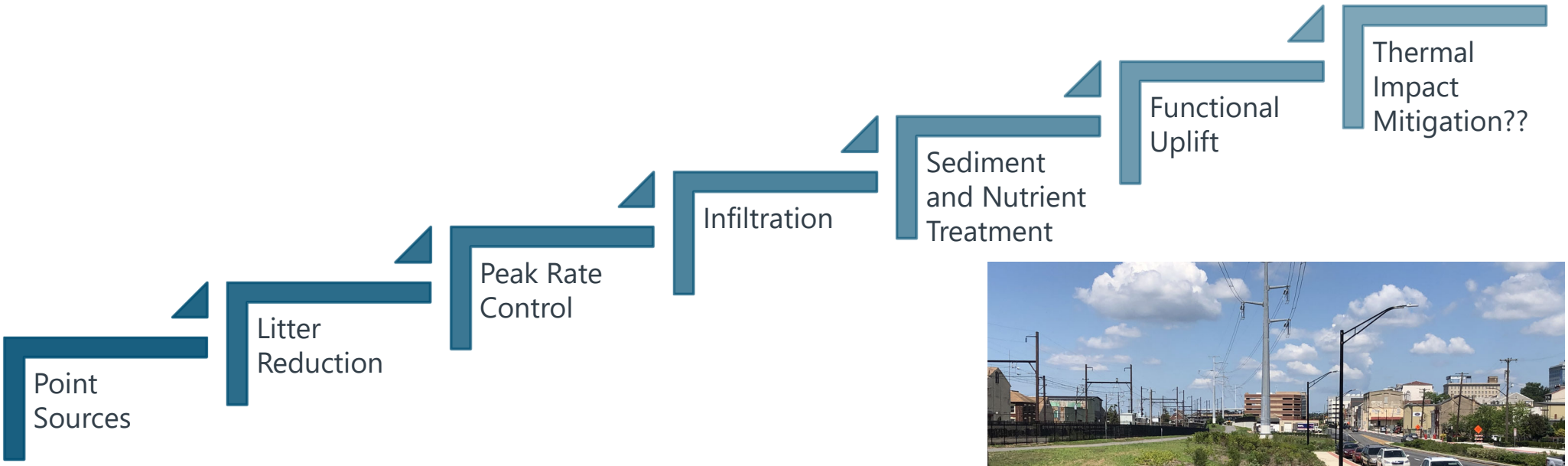
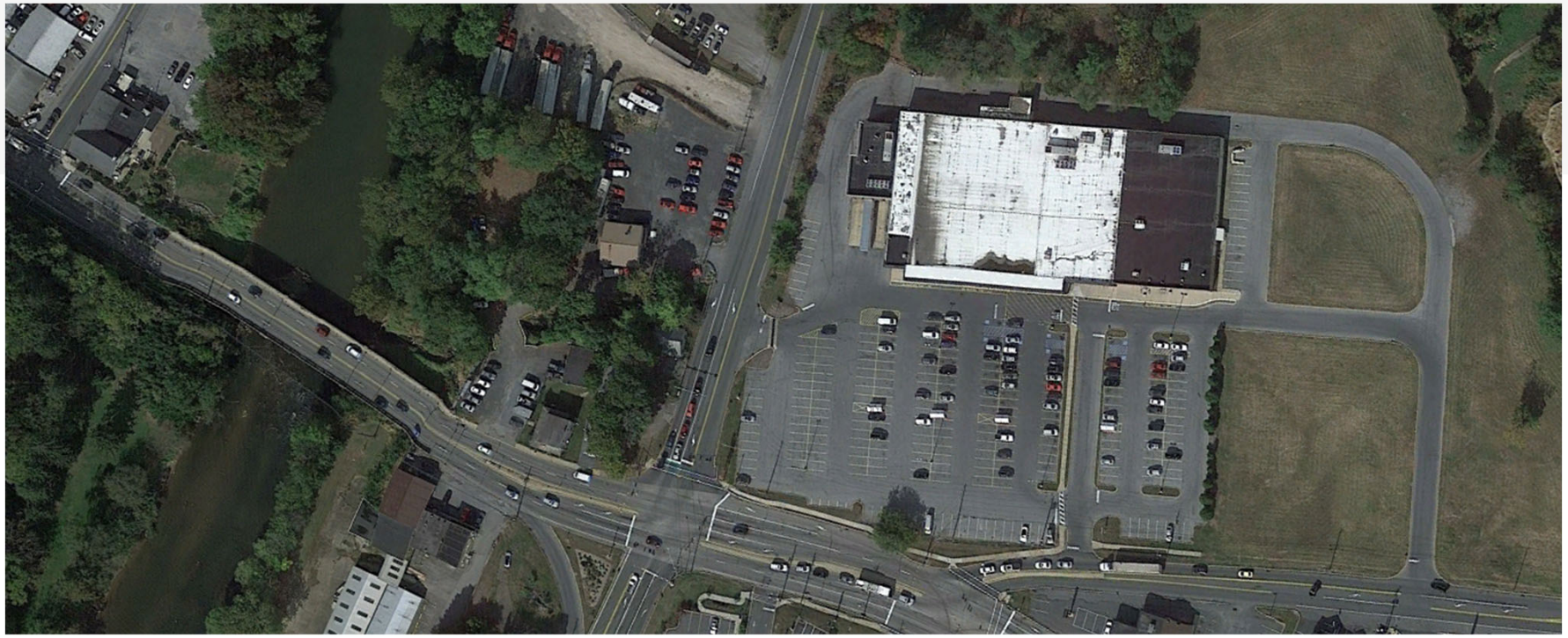
Evolution of minimum water quality standards



How do we prevent stormwater management regulations from being a barrier to desirable development?

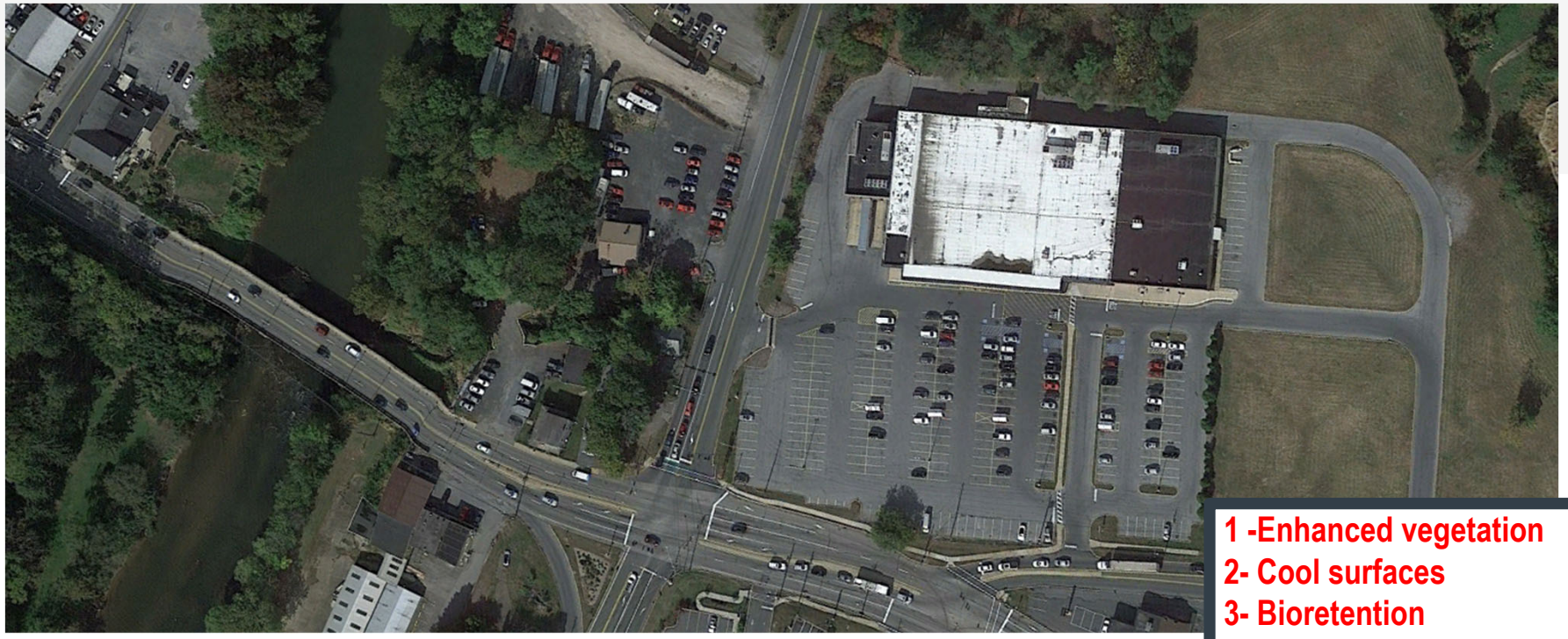


Weis Market (Lincoln Highway):

- 5.5 acres of impervious area
- Developed before 1992
- Expanded before 1999

June 17, 2022

- Rain event: 0.32” in 15 minutes
- <1-year storm, 48,000 gallons of rainfall
- Sky cover: mostly sunny
- 90 degrees
- Estimate 37,000 gallons into the Conestoga River



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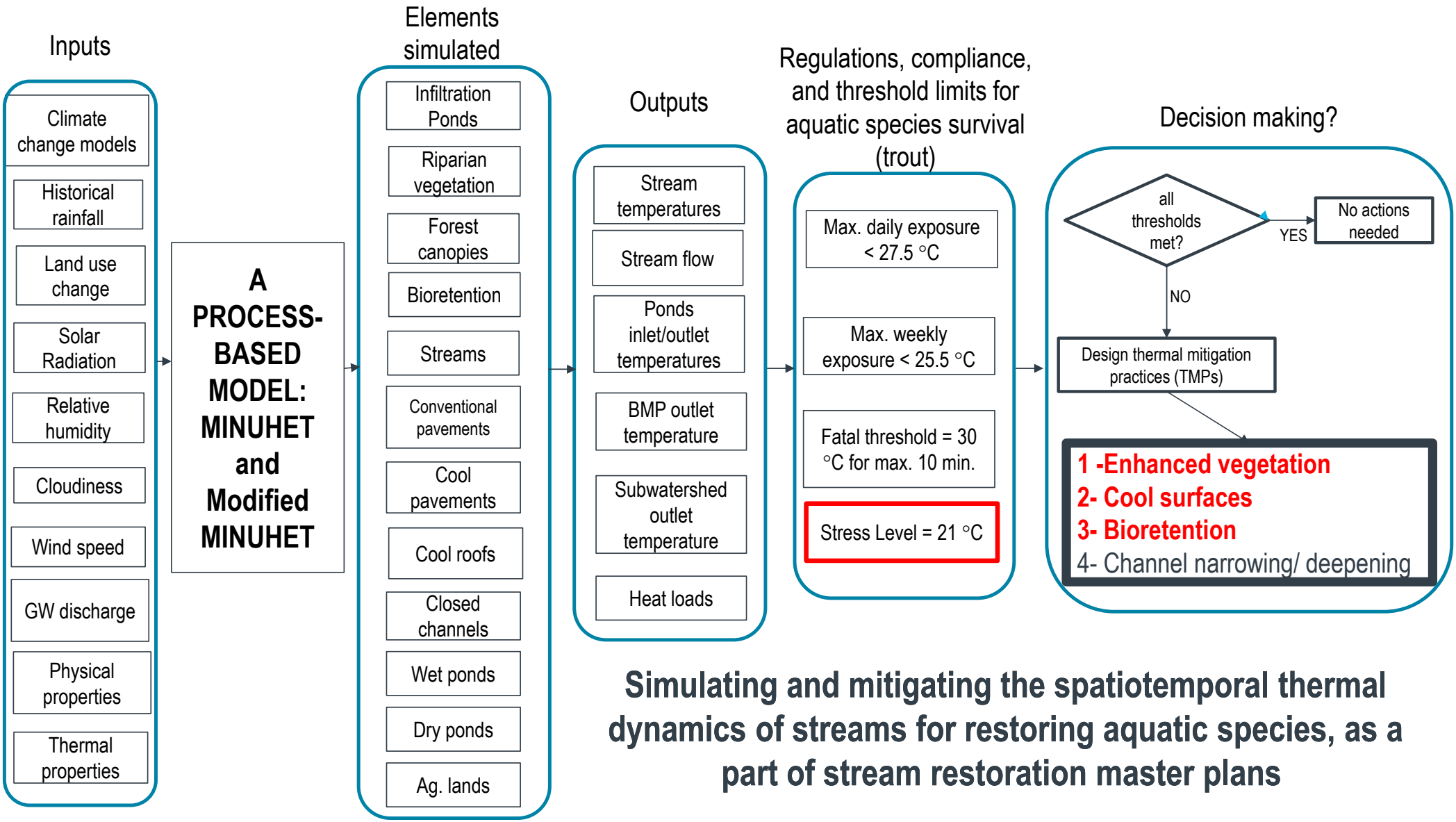
- 90 degrees
- 38,000 gallons into the Conestoga River

Modeling approaches

Goal of the study:
To evaluate the impact of watershed-scale thermal mitigation practices (TMP) on aquatic health given *climate and land use changes*

The first ever-study in simulating watershed-scale TMPs for a large urban watershed based on projected climate and land use change!

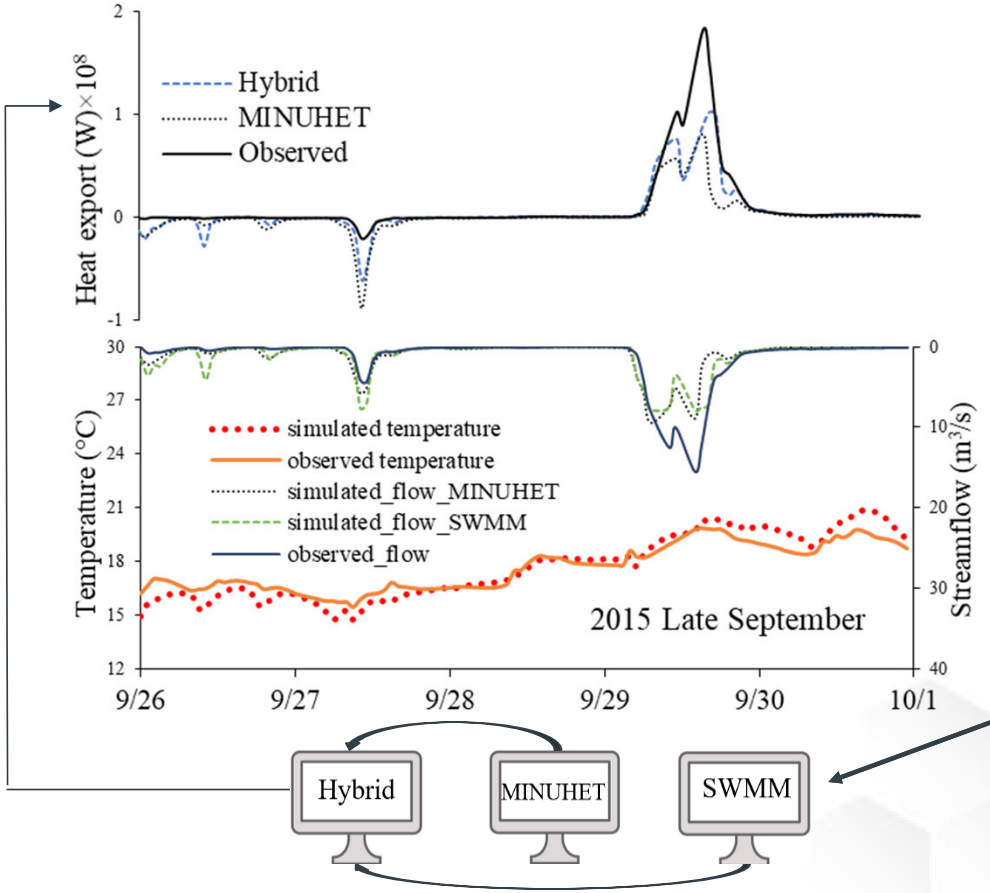


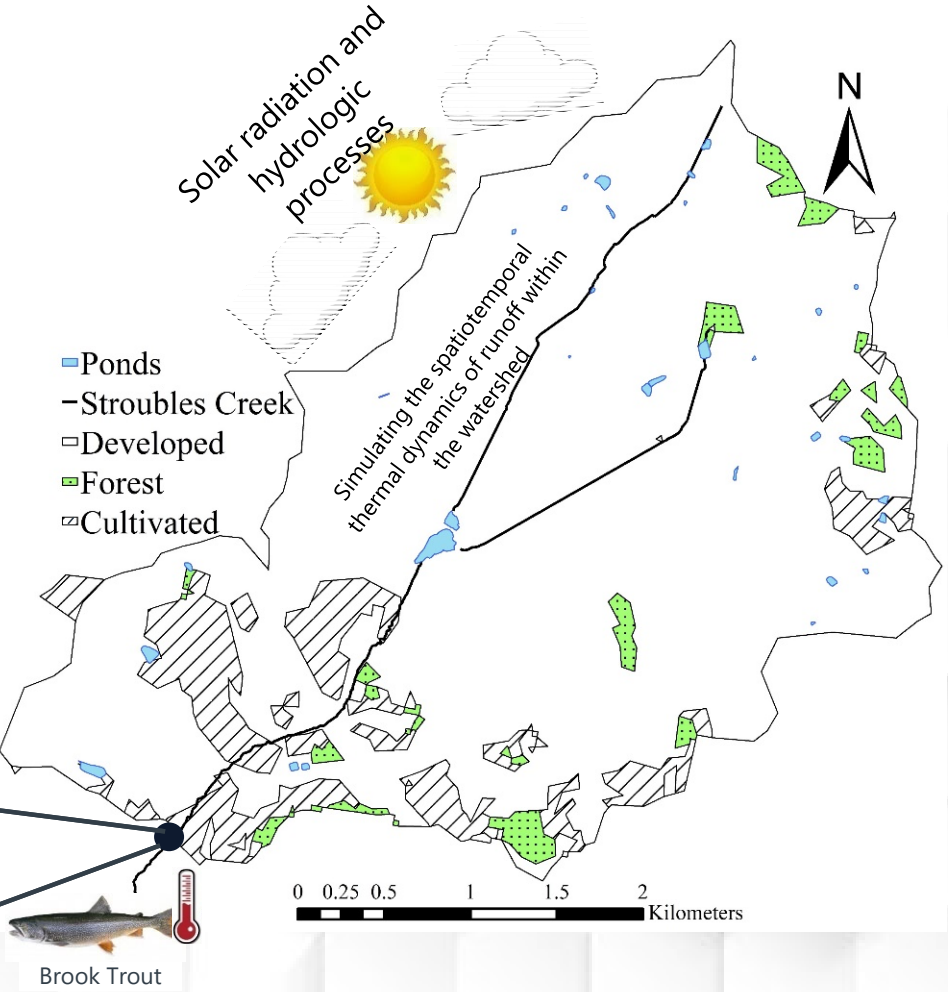
Simulating and mitigating the spatiotemporal thermal dynamics of streams for restoring aquatic species, as a part of stream restoration master plans

Practices that reduce runoff temperatures

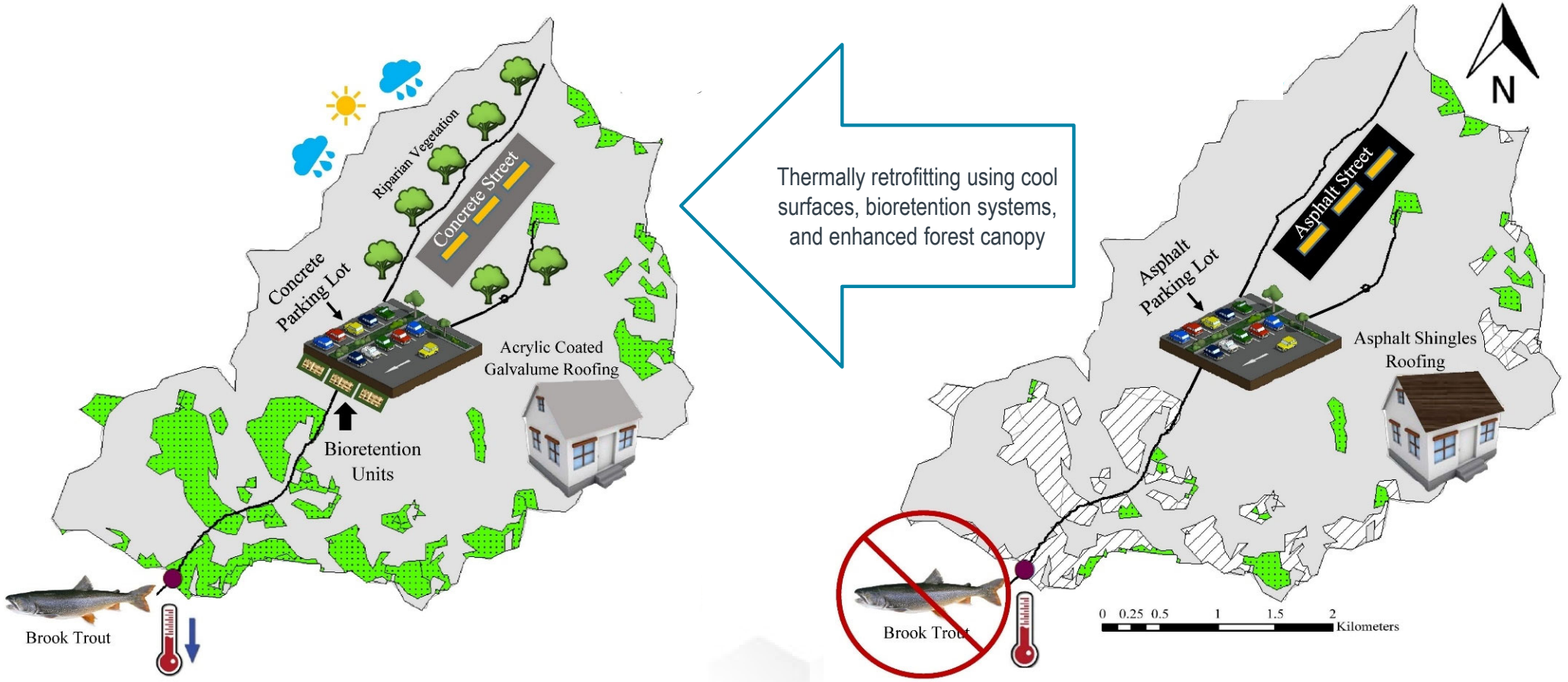
1 -Enhanced vegetation
2- Cool surfaces
3- Bioretention
4- Channel narrowing/ deepening

Case study: Stroubles Creek Watershed, Blacksburg, VA

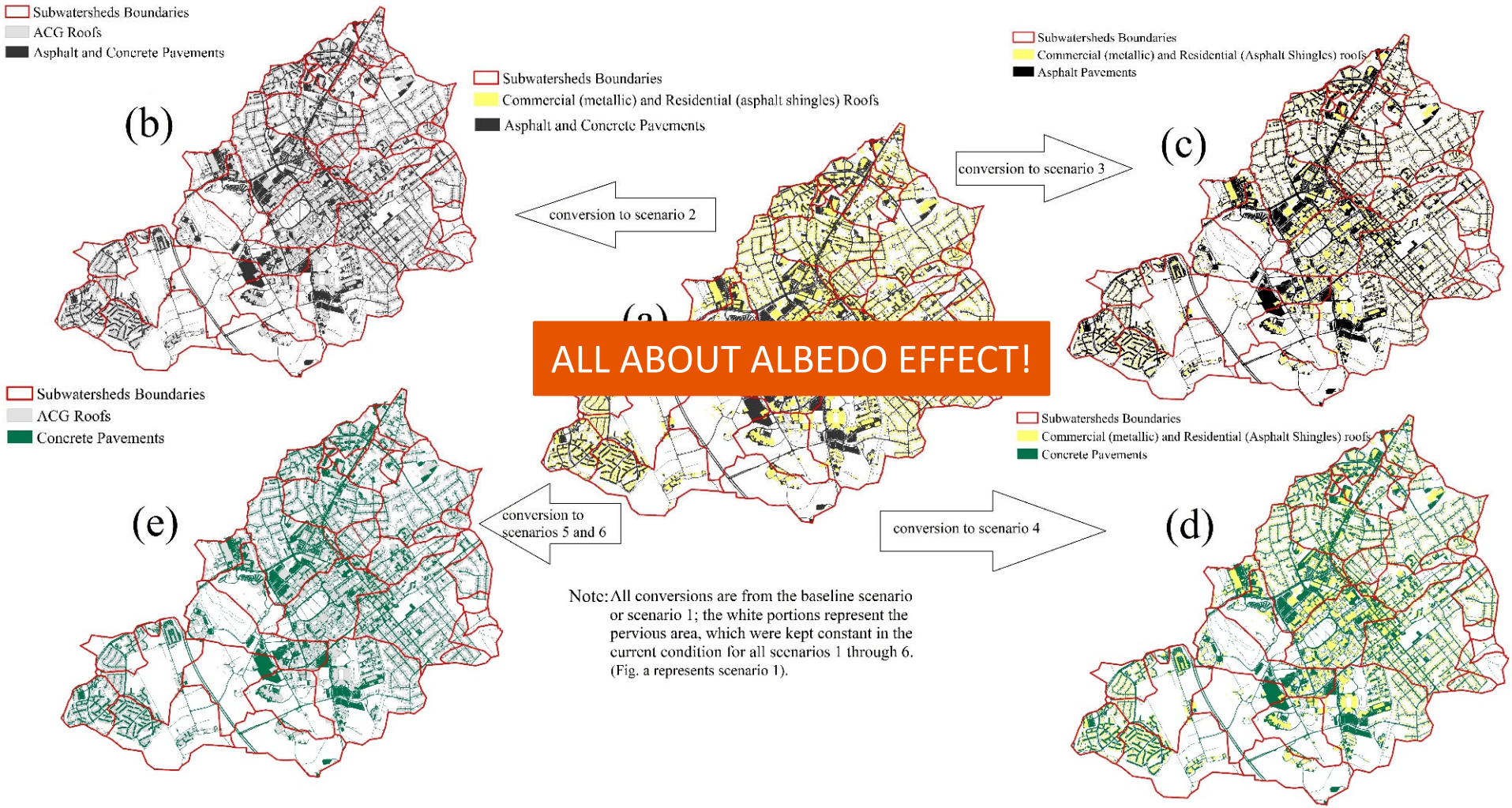


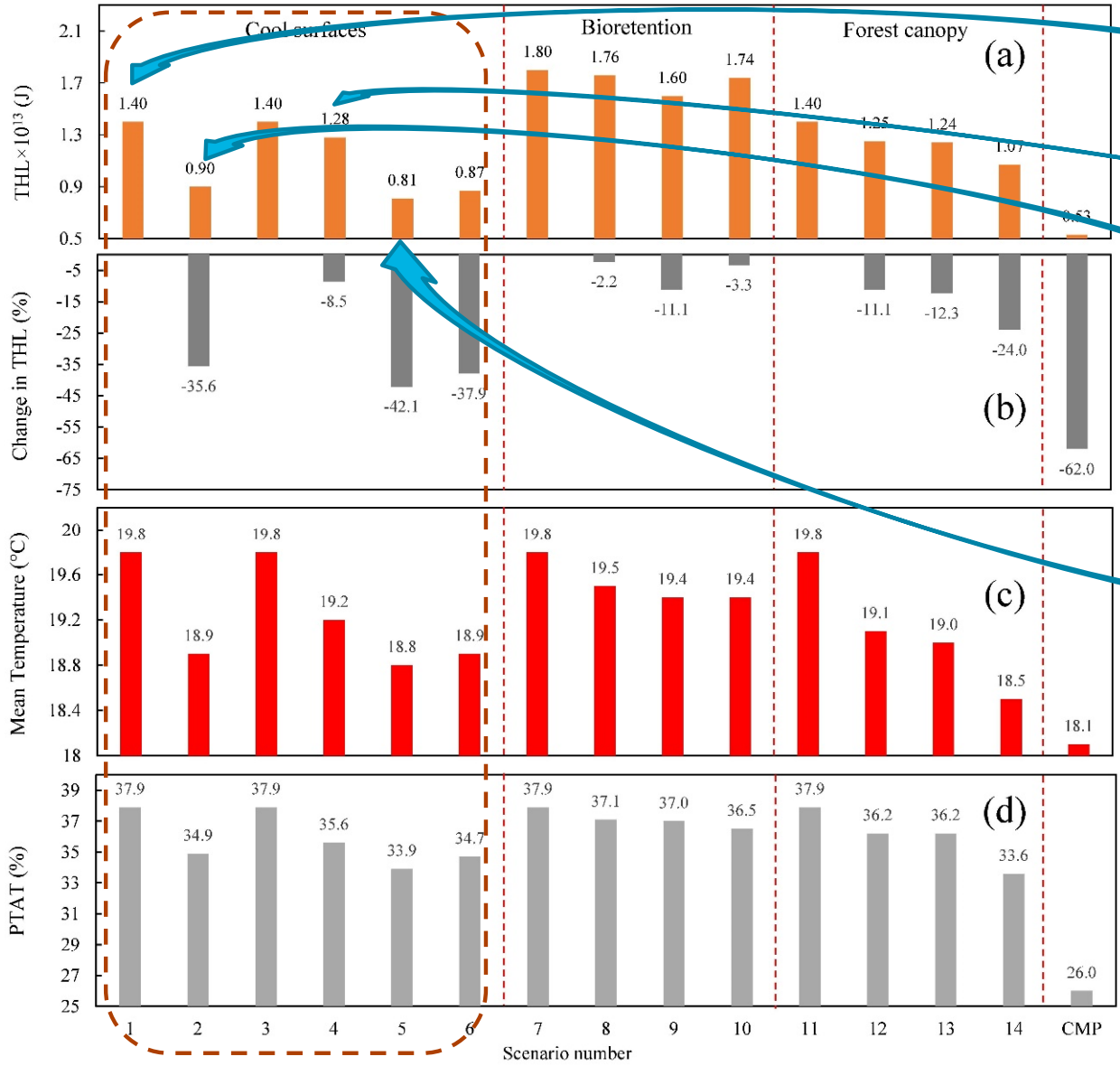


Schematic of TMPs implementation



Cool surfaces implementation





Baseline

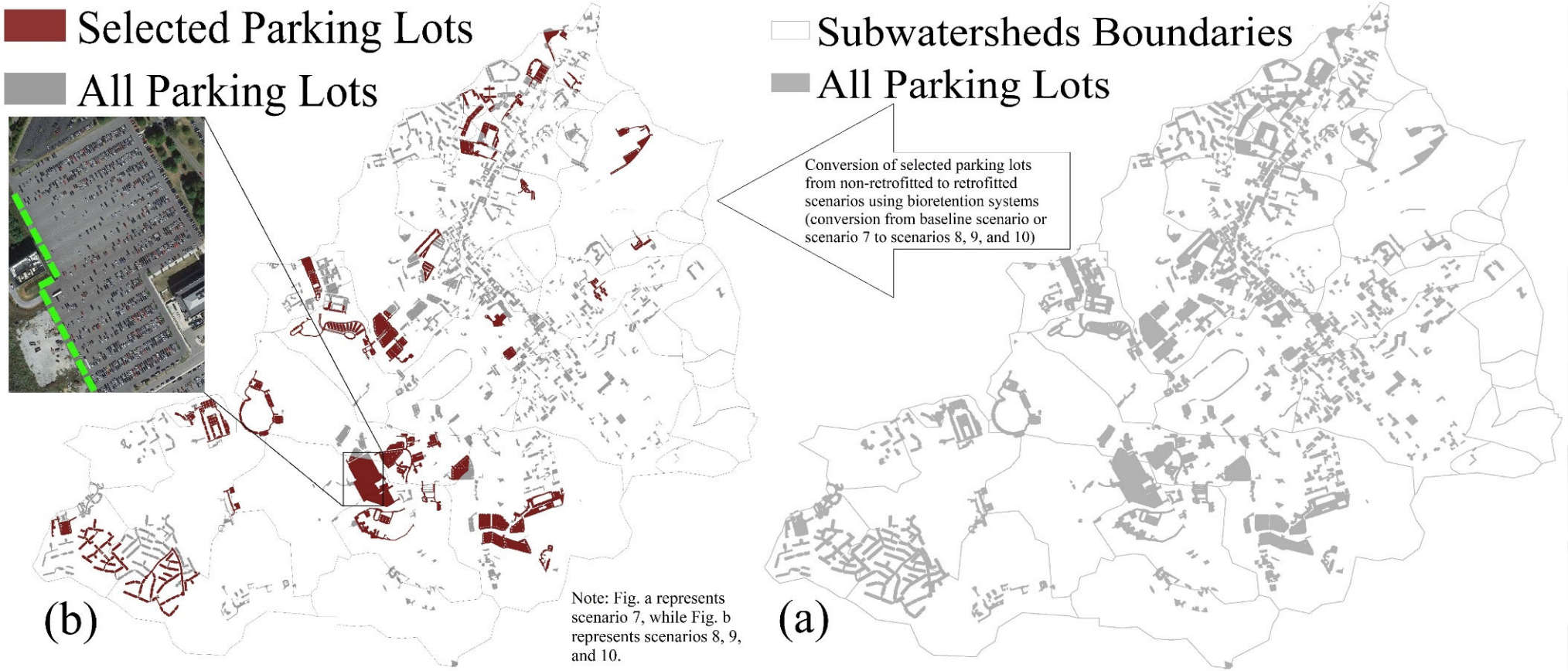
Concrete

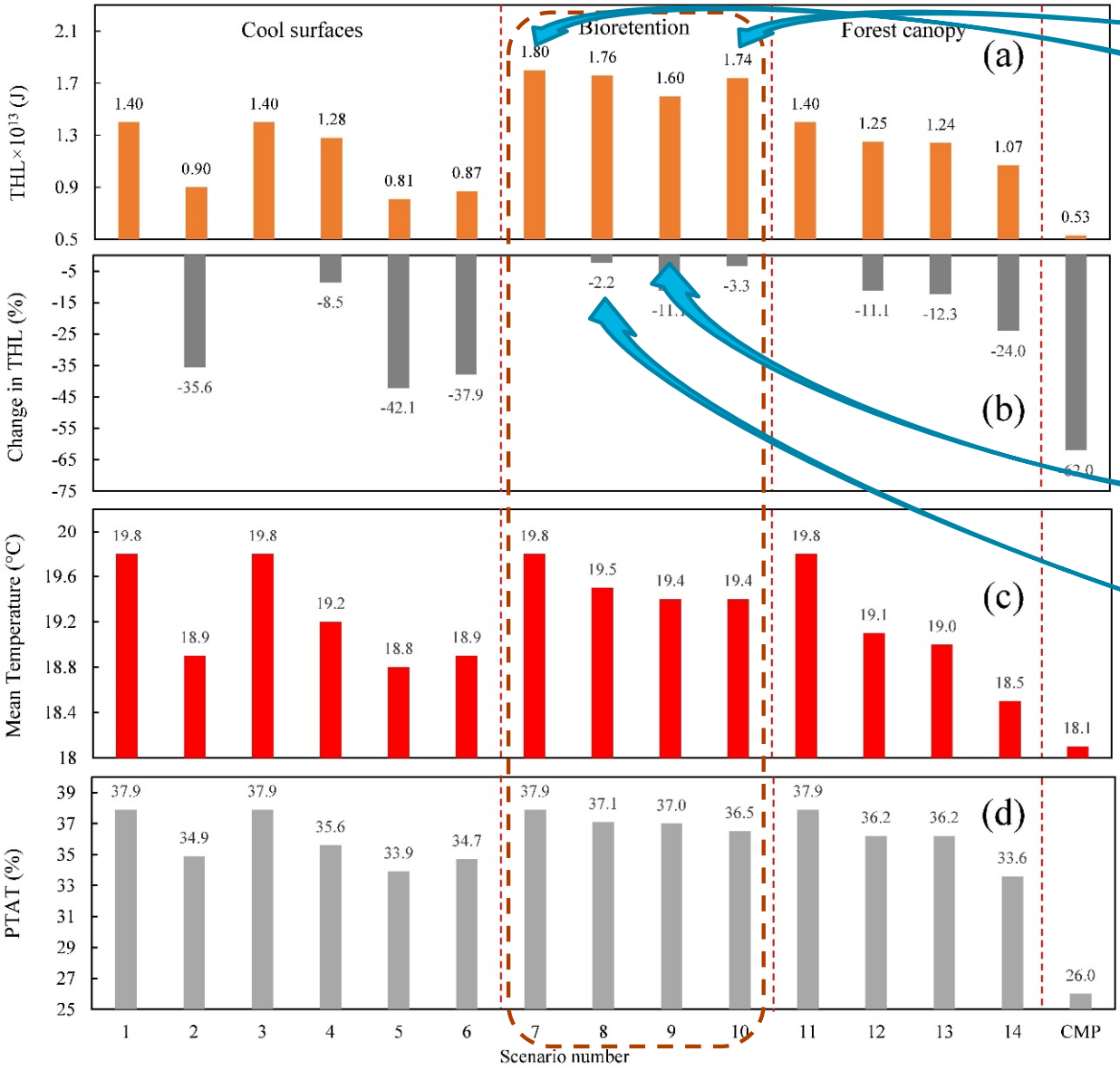
ACG

Combined cool roofs

Results for continuous simulation; summer 2015

Bioretention system implementation





Baseline

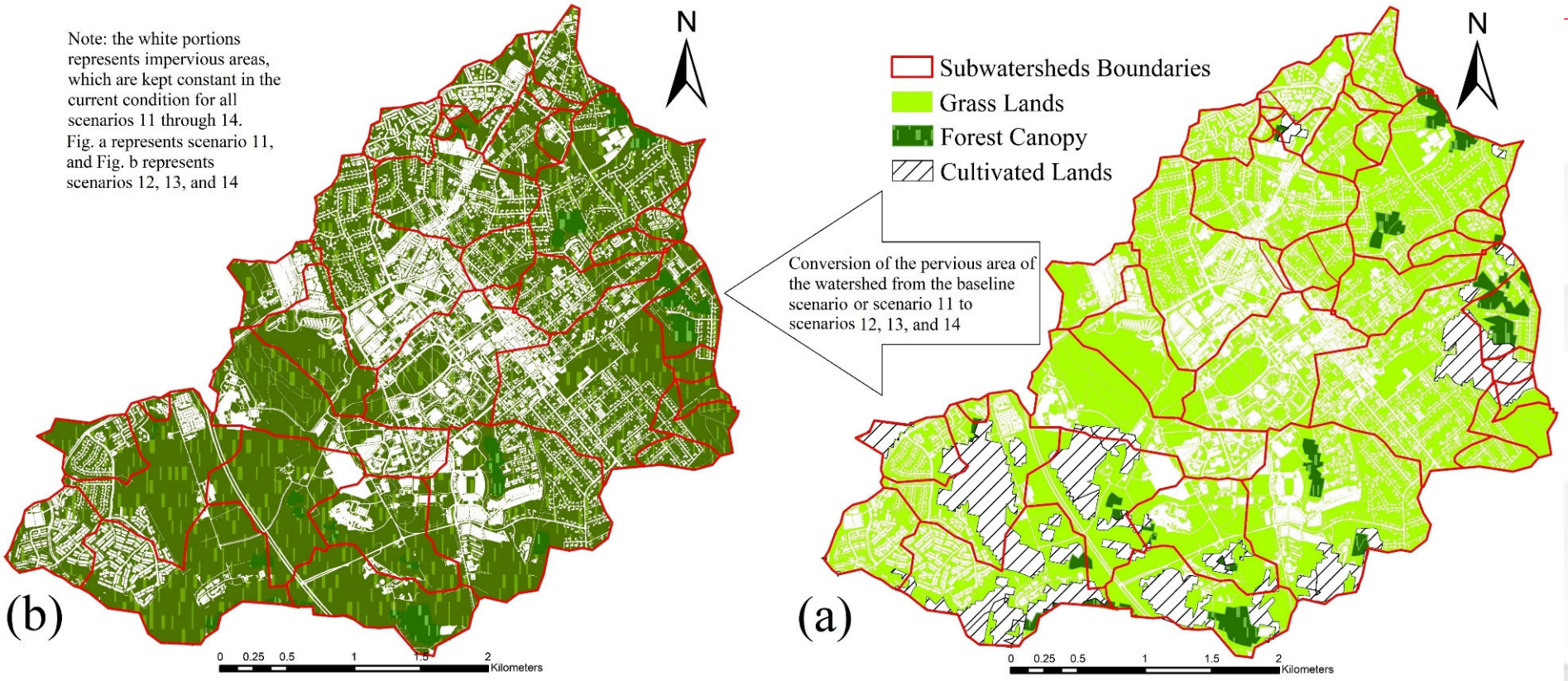
Sandy gravel

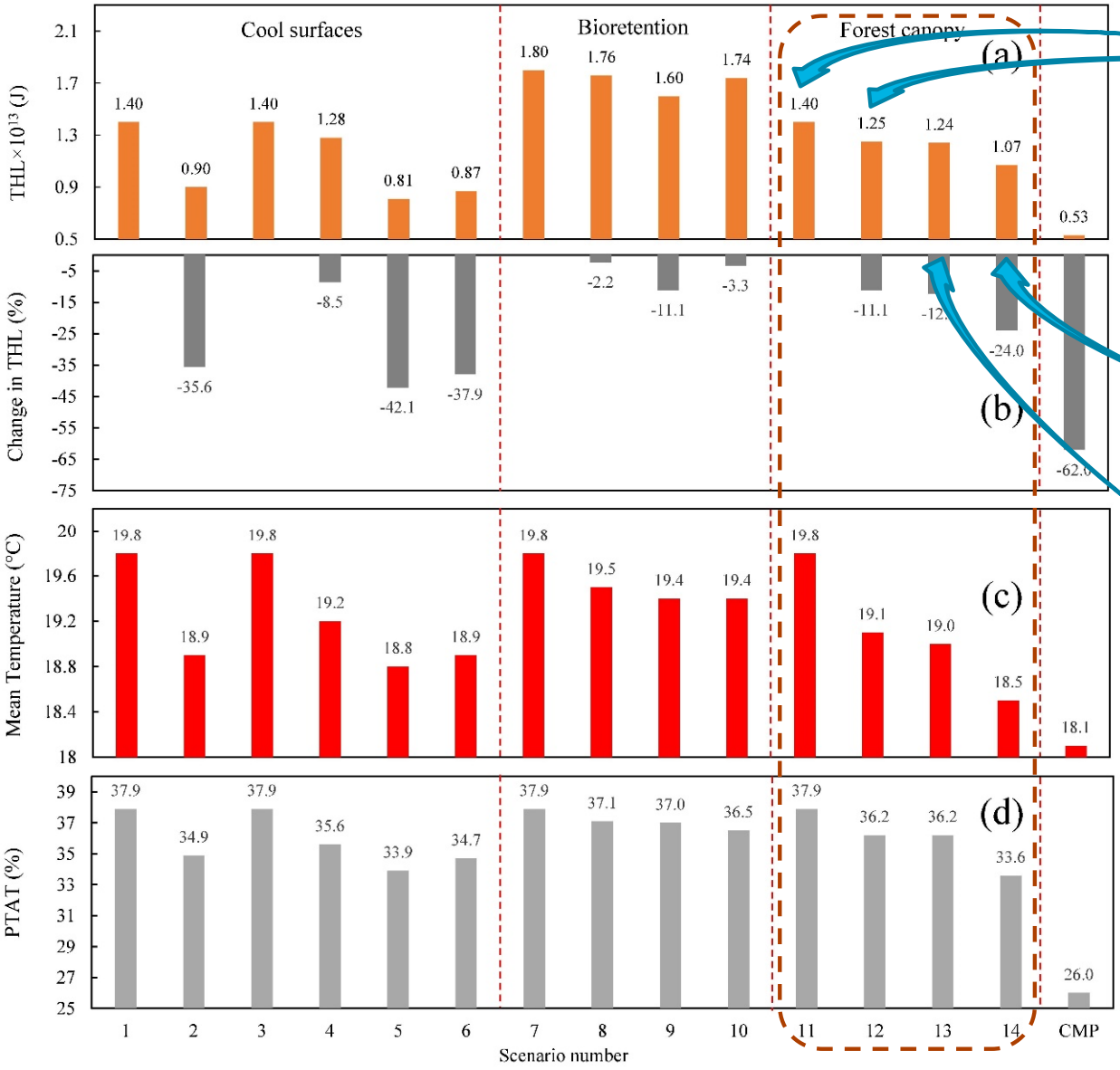
Sand

Sandy clay loam

Results for continuous simulation; summer 2015

Enhanced forest canopy implementation





Baseline

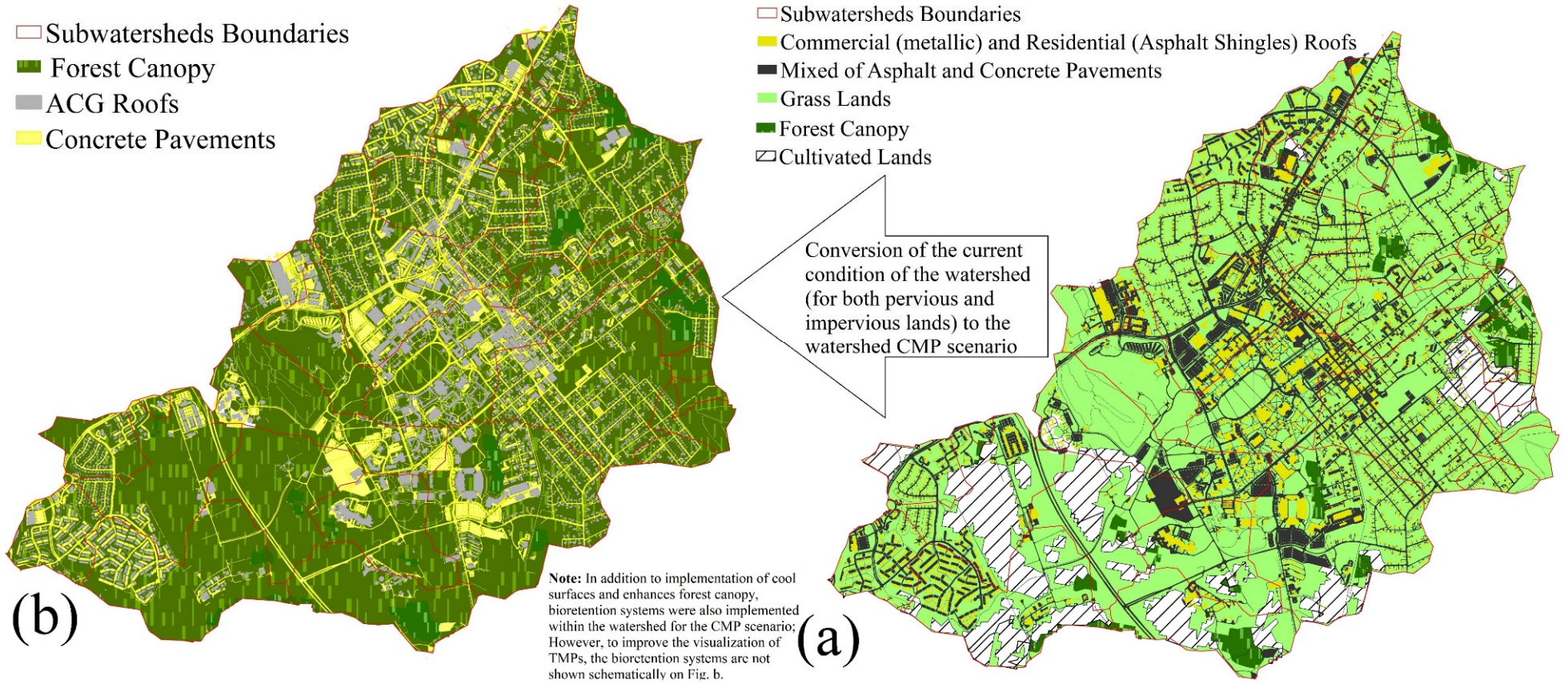
F.C. 1

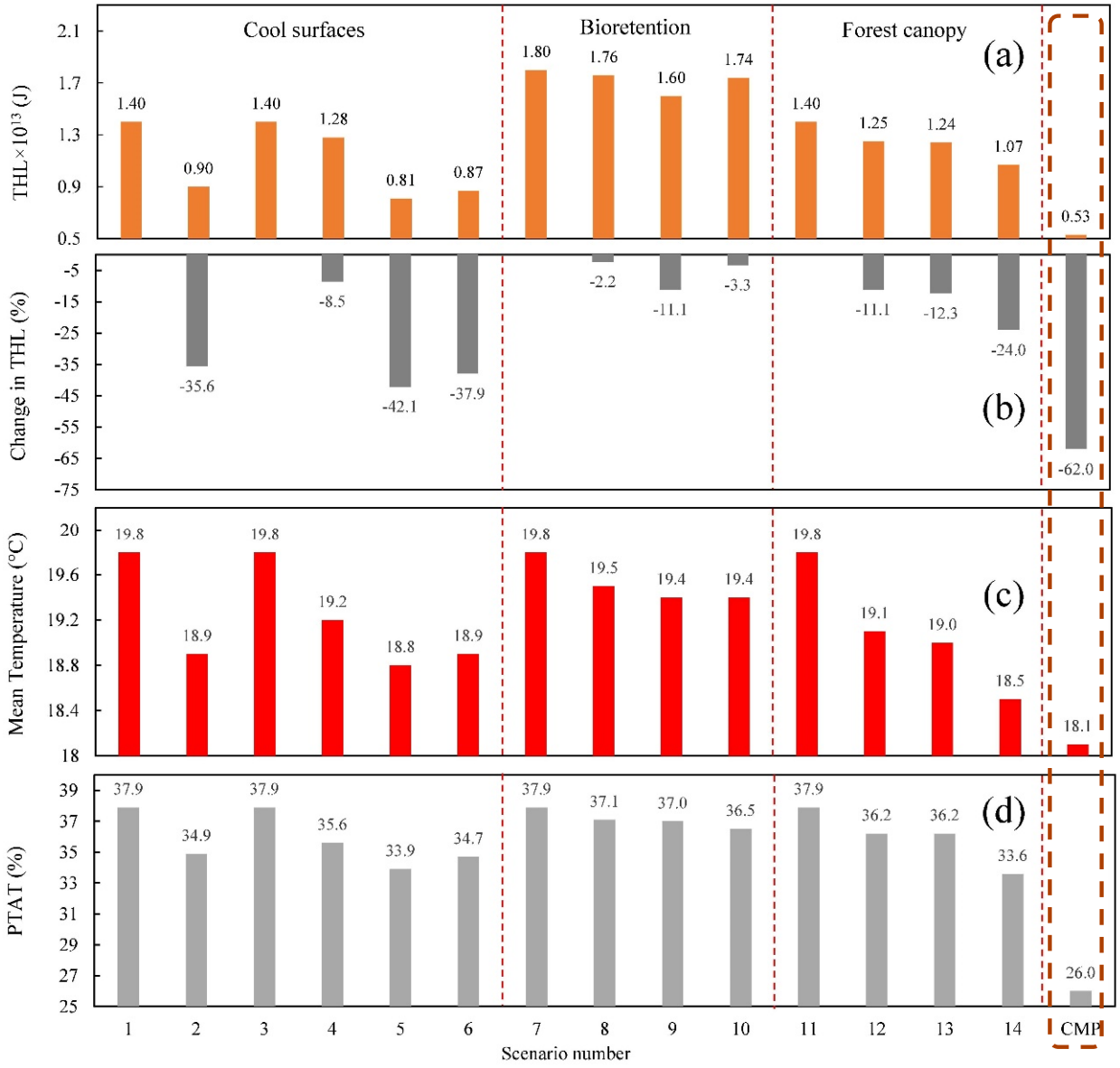
F.C. 3

F.C. 2

Results for continuous simulation; summer 2015

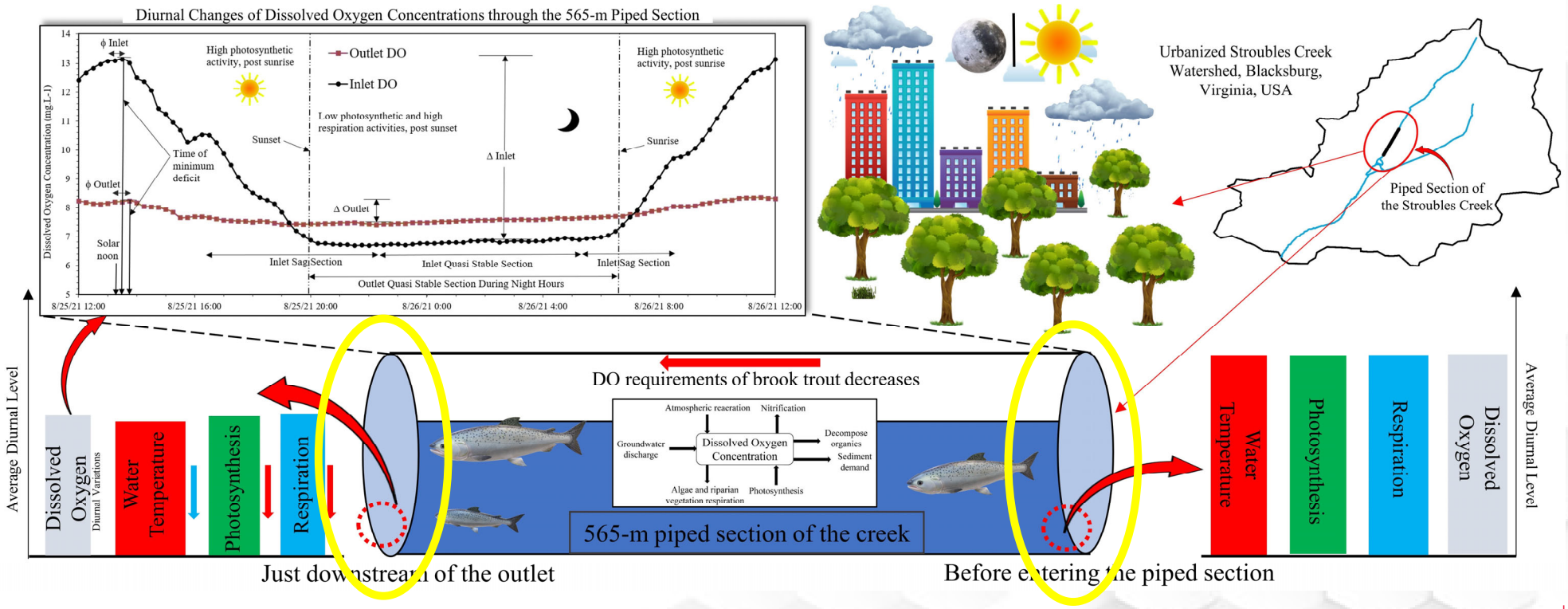
Comprehensive mitigation plan



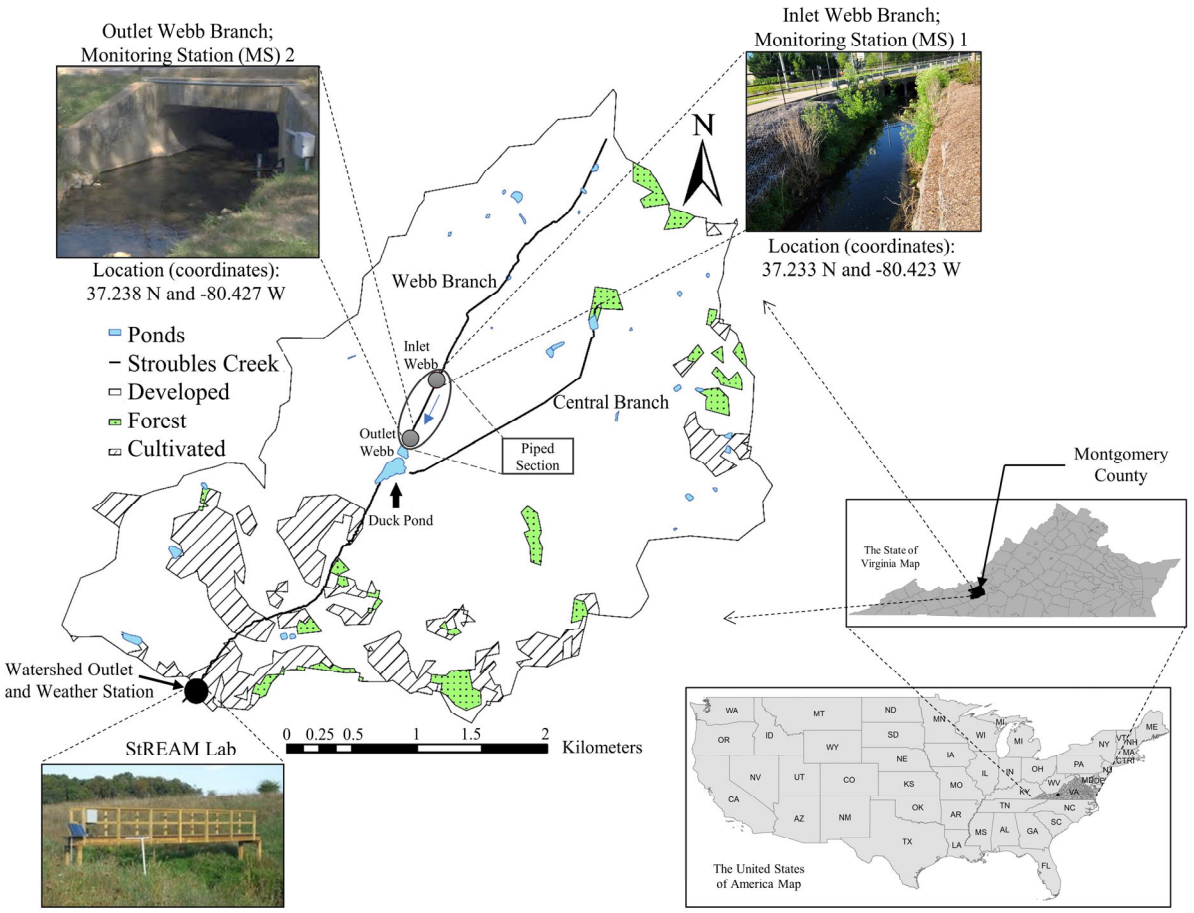


Results for continuous simulation; summer 2015

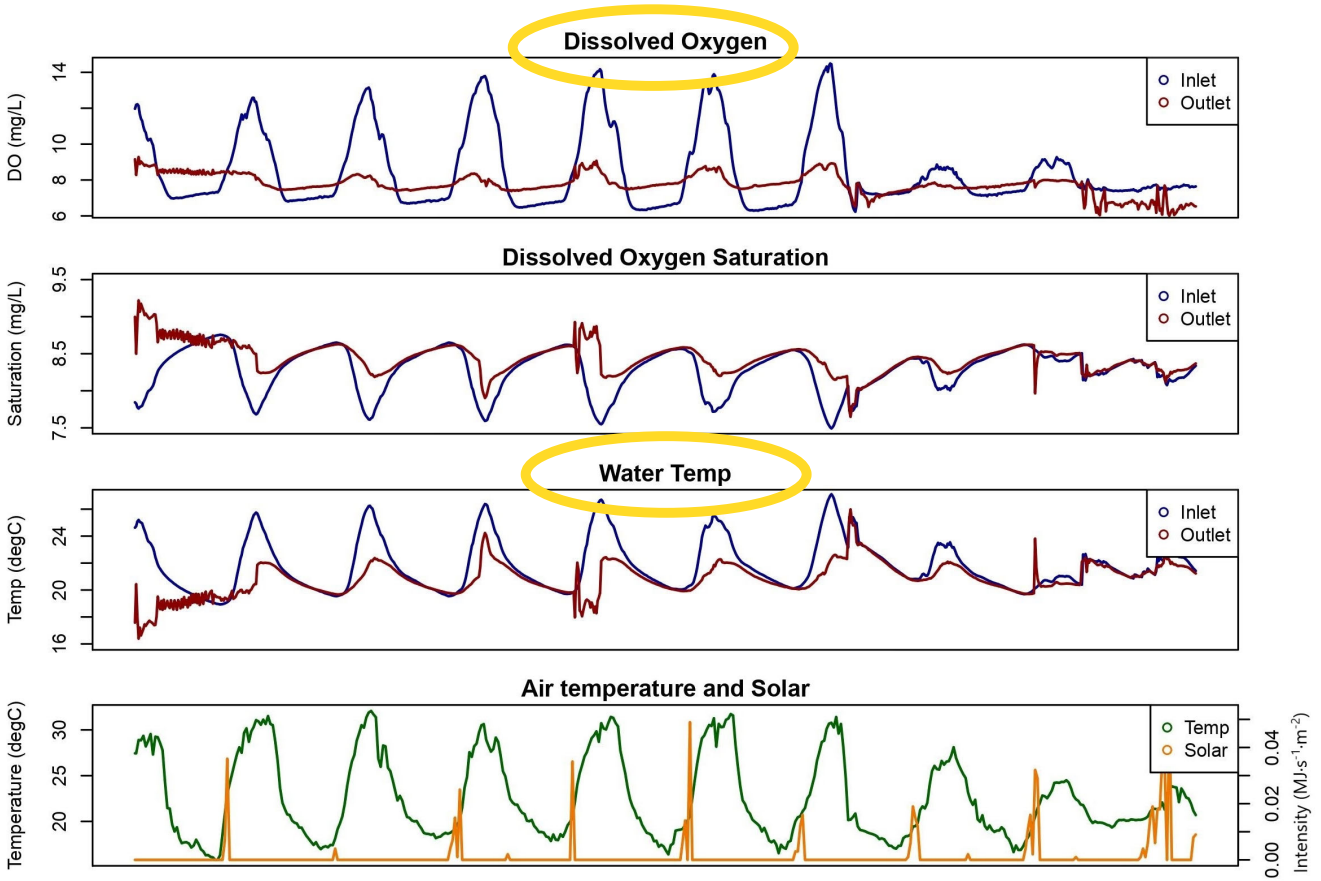
CHANNELIZATION EFFECT: Interaction of stream temperature, piping channels, and dissolved oxygen



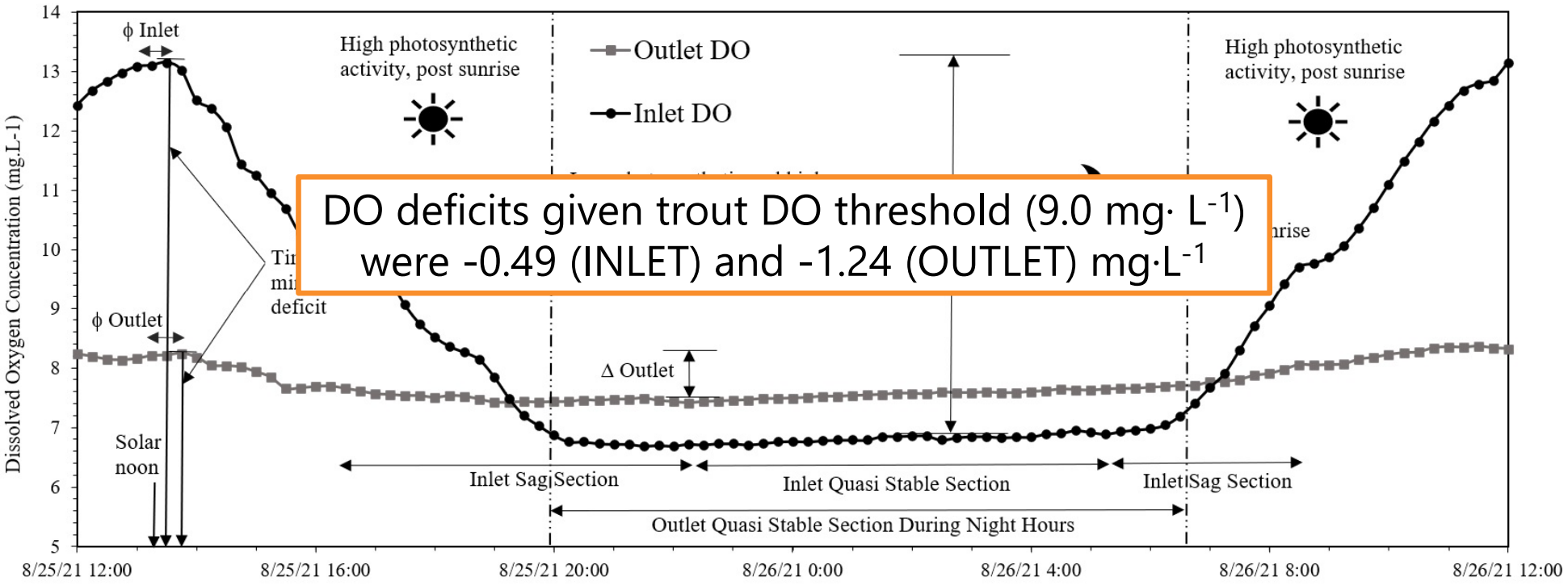
Interaction of stream temperature, piping channels, and dissolved oxygen



Interaction of stream temperature, piping channels, and dissolved oxygen



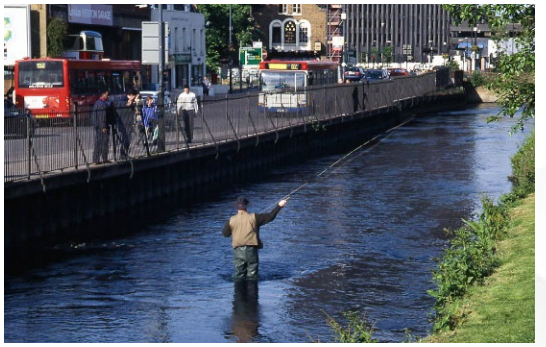
Interaction of stream temperature, piping channels, and dissolved oxygen



DO deficits given trout DO threshold (9.0 mg· L^{-1}) were -0.49 (INLET) and -1.24 (OUTLET) mg·L^{-1}

Thermal mitigation practice applications for combating climate and land cover changes:

1. Urban streams where aquatic habitats are vital and there is no room for excessive riparian vegetation

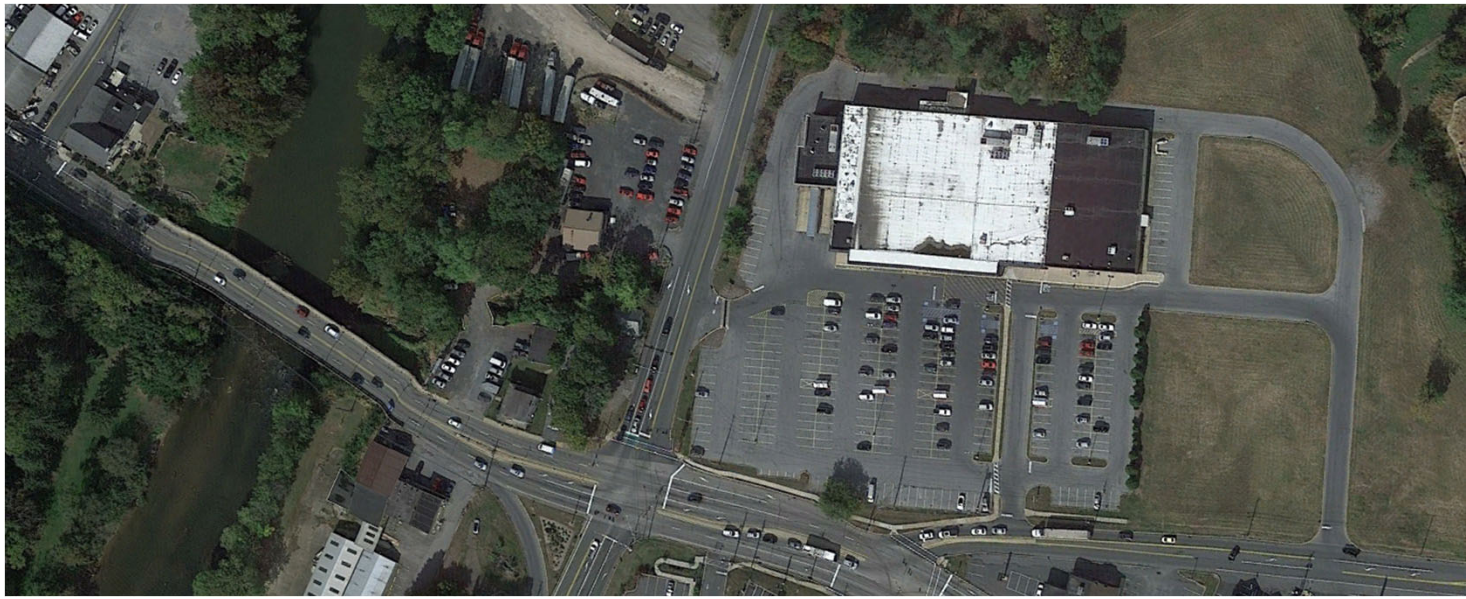


2. Streams receiving slugs of highways thermally enriched runoff

3. Streams in deforested watersheds

Research Summary

- EPA and NOAA present climate change-induced extreme rainfall patterns, which can contribute to thermal loading of surface waters
- Thermal pollution models incorporate heat island, climate change, and land use change inputs
- Mitigation strategies have different results on reducing thermal pollution
- Changing land cover will impact stream temperature, dissolved oxygen, and ecological health



Our published works and references

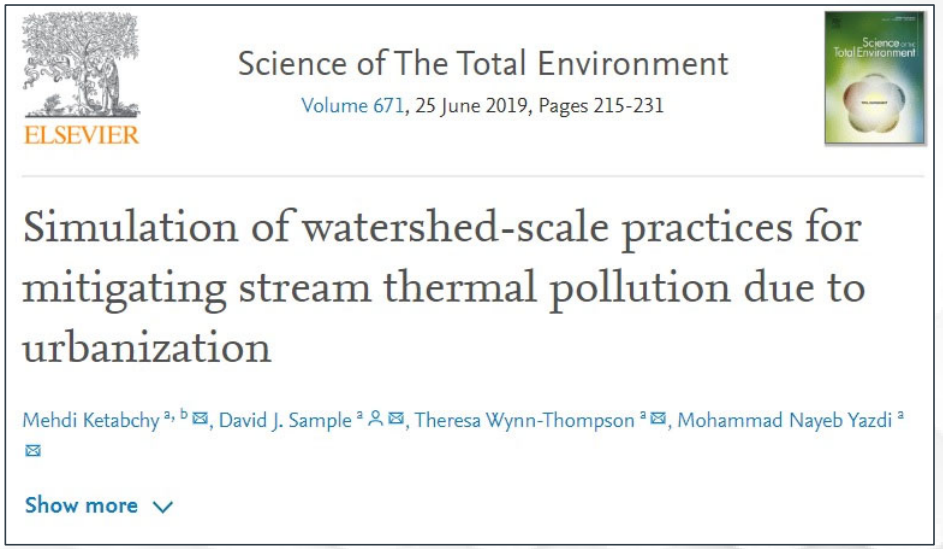
Submitted to the Environmental Pollution

The effect of piping stream channels on dissolved oxygen concentrations and ecological health

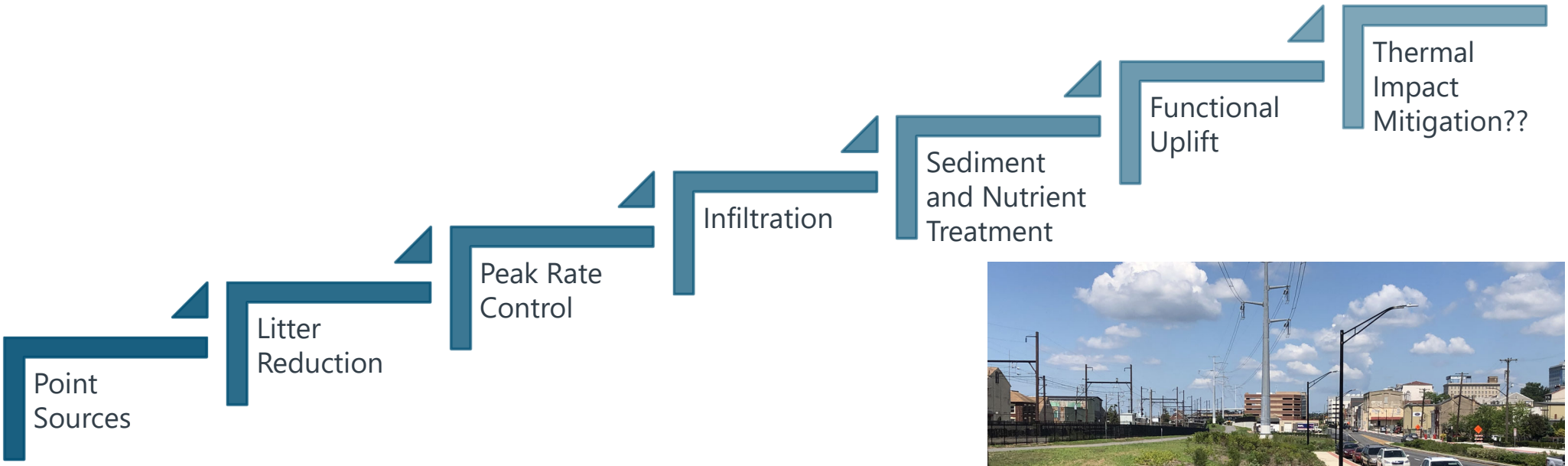
Mehdi Ketabchy[1,2], Elyce N. Buell[3], Mohammad Nayeb Yazdi[3], David J. Sample[3,*], Mina Shahed Behrouz[3]

[1] *Department of Civil and Environmental Engineering, University of Maryland, College Park, MD, United States*
[2] *Roadway Business Line, Gannett Fleming, Inc., Baltimore, MD, United States*
[3] *Department of Biological System Engineering, Virginia Polytechnic Institute and State University, VA, United States*

Collaborators from Gannett Fleming, City of Arlington, Virginia Tech, University of Maryland at College Park, and Ohio State University



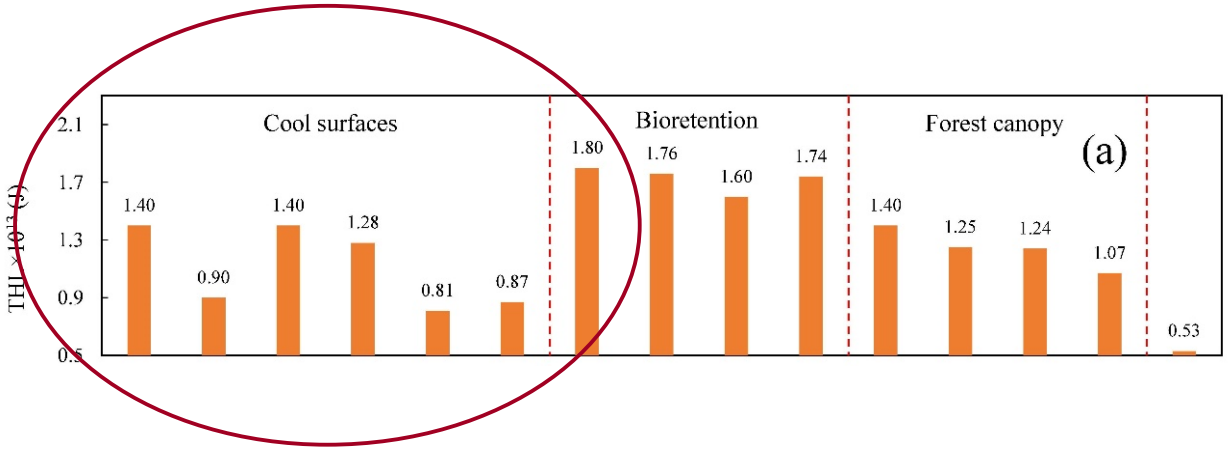
Evolution of minimum water quality standards



How do we prevent stormwater management regulations from being a barrier to desirable development?

Discussion

- Traditional basins may actually increase temperature of streams
- Groundwater infiltration through green stormwater infrastructure may only address small storms
- Forest canopy and Low Impact Development techniques are hard to apply in developed areas
- Urban greening is a useful tool – and the benefits and costs are broadly discussed
- Cool surfaces have promise – but how do you regulate and what is the cost?



1 -Enhanced vegetation
2- Cool surfaces
3- Bioretention
4- Channel narrowing/ deepening

How do we prevent stormwater management regulations from being a barrier to desirable development?

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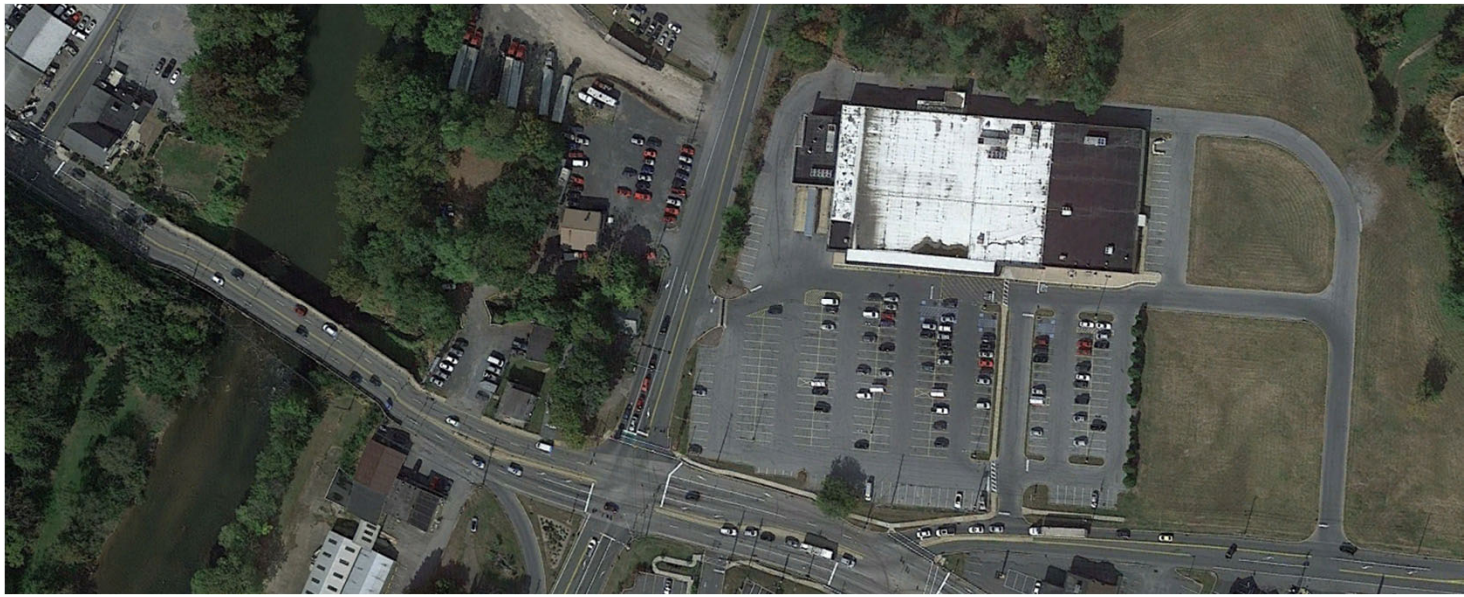
Closing

- Stormwater regulations intend to protect dissolved oxygen via water chemistry
- Water temperature is an emerging concern
- Will new water quality regulations address this threat?
- How do we prevent stormwater management regulations from being a barrier to desirable development?
- Modeling can show which practices are most effective at reducing thermal pollution



GANNETT FLEMING

HOT TOPIC:
URBAN HEAT ISLANDS AND IMPACTS TO WATER AND LAND USE REGULATIONS

Presented by:
Nathan Walker, AICP, Sr Water Resources Planner
Mehdi Ketabchy, EIT, ENV SP, Water Resources Engineer

PA Chapter of the American Planning Association

Annual Conference, Lancaster, PA

October 3, 2022, 3:45 – 5:15pm